SIR WILLIAM RAMSAY, K.C.B., F.R.S.

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SIR WILLIAM RAMSAY

K.C.B., F.R.S.

MEMORIALS OF HIS LIFE AND WORK

4

BY

SIR WILLIAM A. TILDEN, F.R.S.

VIVIT POST FUNERA VIRTUS

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PREFACE

Every reader of this volume will at once perceive that its compilation would have been impossible but for the active co-operation of many friends. Foremost among them was, of course, Lady Ramsay, who has not only placed at the disposal of the writer the immense collection of letters preserved by herself and by members of the family on both sides, but she has contributed many facts and incidents, and with her own pen has set down her recollections of the journeys taken with her husband to the West and to the East.

The source of quotations inserted in the text has been indicated in each case, but the writer is under special obligations for the use of correspondence and for interesting recollections of early days in Ramsay's life to Mr. H. B. Fyfe, of Glasgow, his life-long friend and legal adviser, and to Sir James Dobbie, his early pupil and associate in chemical research, also to Professor Sydney Young, Ramsay's assistant at Bristol and colleague in research during a period of some seven years, while Professor Hicks, of Sheffield, has kindly supplied much information relative to the progress of the movement

which ultimately resulted in obtaining pecuniary assistance for university colleges from the Government.

To Lord Rayleigh the writer desires to express his best thanks, for kindly consenting to read the MS. of that part of Chapter V. which relates to the discovery of argon, and for notes thereon, which have been embodied in the text.

Mr. W. G. Ramsay has taken the trouble to compile the chronological list of honours conferred on his father, which will be found at the end of the book.

The long series of letters addressed by William Ramsay to his cousin, Miss Ramsay, the eldest daughter of his uncle, the late Sir Andrew C. Ramsay, has afforded much insight into his character and the intimate relations subsisting in the family.

Among other friends who have supplied information, or have allowed the use of letters, are the following: Mr. James Rafter, the Registrar of the University of Bristol; Professor E. C. C. Baly, F.R.S., of Liverpool University; Professor J. Norman Collie, F.R.S., Professor F. G. Donnan, F.R.S., and Professor W. P. Ker, of University College, London; the Provost of University College (Sir T. Gregory Foster); Mr. Otto Hehner, Dr. George M'Gowan, Miss F. MacVicar, Mrs. M'Nicol, Mr. M. M. Pattison Muir; Professor Alfred Marshall, of Cambridge; Professor Lloyd Morgan, F.R.S., of Bristol; Sir Henry A. Miers, F.R.S., Principal of the University, Manchester; Mr. B. J. Padshah; Lieut.-Colonel A. lls, F.R.S., of Leeds; Professor F. Soddy, F.R.S., berdeen University; Mrs. John Baird Smith, Mr.

William Turnbull, Mr. Robert Dowie Urquhart, Mrs. Worthington, and Dr. Morris Travers, F.R.S.

Thanks are also due to the Council of the Chemical Society for permission to photograph the portrait opposite the title-page and to the Council of the Royal Society for the figures of apparatus. Professor John M. Thomson, F.R.S., has kindly supplied the excellent portrait taken by him in 1912.

A word of explanation may also be looked for in regard to the authorship of the volume. Late in the autumn of 1916 I was requested by the Professors in the Chemical Department of University College to undertake the work. This may have been suggested by the fact that I had already prepared hastily an obituary notice for the *Journal of the Society of Chemical Industry* by desire of the Council of that Society. I did not, however, feel at liberty to undertake the task until I had been assured that my doing so would be consonant with the wishes of Lady Ramsay. I cannot refrain from offering to her an expression of more than ordinary thanks for the privilege, as I regard it, of being admitted to the view which I now have of her brilliant husband's life and character. I can claim an acquaintance with him of more than thirty-five years, and I can boast of a friendship of at least twenty-five. Nevertheless, I feel that it is only now that I know something of the man. The long series of letters which have been preserved, extending over nearly fifty years, many of them written in the full confidence of youth and a close intimacy with friends and relations, reveal the dominant

features of his character, which are quite in accord with the estimation formed by the friends who knew him from earliest days. The contents of some of these letters, especially to his wife, are too sacred to be quoted, but they have left deep impressions on my mind, and these I have endeavoured to indicate in the book.

Since the beginning of the war it has become more than ever obvious that in the interest of national industries a larger number of able young men and women should be induced to take up the study of chemistry with a serious view to the applications of the science. But it is clear that for this purpose assistance must be given in many cases to enable promising students to follow to the end the protracted course of study necessary. And it is with this object that the movement for a "Ramsay Memorial" has resulted in the scheme which includes provision of opportunities for further study by advanced students of chemistry. It is even hoped that the idea of founding a Ramsay Memorial Fellowship may assume an international character. There is every reason for believing that the scheme would have received approval from Sir William Ramsay himself, with probably two conditions, namely, that the Fellows selected should be chosen by some method which does not involve competitive examination, and that they should devote the greater part of their time during tenure of the Fellowship to scientific research.

W. A. T.

NORTHWOOD, *February*, 1918.

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BIOGRAPHICAL NOTES

1852 William Ramsay, born 2nd October at Queen's Crescent, Glasgow, the only child of William Ramsay and Catherine Robertson.

1863 Joined the Third Latin Class of the Glasgow Academy.

1866 Entered the University in November.

1869 Entered R. R. Tatlock's laboratory, attending at the same time lectures at the University on Physics, Chemistry, Anatomy and Geology.

1870 In Bunsen's laboratory at Heidelberg.

1871 Easter, proceeded to Tübingen.

1872 August, returned to Glasgow, and appointed Assistant in the Young Laboratory of Technical Chemistry.

1874 Appointed Tutorial Assistant in Glasgow University under Professor John Ferguson.

First independent paper (*Journ. Chem. Soc.* p. 857), "On Hydrogen Persulphide."

1880 Professor of Chemistry, University College, Bristol.

1881 Principal of the College.

Married, August, to Margaret, daughter of George Stevenson Buchanan.

1883 First paper of series jointly with Dr. Sydney Young.

1887 Professor of Chemistry, University College, London.

1894 Isolation and study of argon in association with Lord Rayleigh.

1895 Discovery of terrestrial helium.

Awarded the Davy Medal by the Royal Society.

1897 President of the Chemical Section of the British Association at Toronto.

Awarded the Longstaff Medal by the Chemical Society.

1898 Discovery of neon, krypton and xenon.
1900-1901 To India.
1902 K.C.B.
1903 Recognition of helium as product of the disintegration of radium emanation.
President of the Society of Chemical Industry.
1904 Awarded the Nobel Prize for Chemistry.
President of the Society of Chemical Industry.
1905 Discovery of radio-thorium.
1907-8 President of the Chemical Society.
1908-9 President of the Chemical Society.
1909 President of the International Congress of Applied Chemistry.
1910 Determination of density of niton (radium emanation).
1911 President of the British Association.
1912 Retires from Chair at University College.
1916 Last communication to the Royal Society.
Death, 23rd July.

CHAPTER I

CHILDHOOD AND YOUTH

The Chinaman, whose religion teaches him to reverence the memory of his ancestors, has for ages given in the performance of his devotions an explicit recognition of a principle which only in comparatively recent times has been the subject of much notice in the western world. Everyone now knows that all qualities and powers for good or ill are the products of heredity.

> "Born into life, man grows
> Forth from his parents' stem,
> And blends their bloods, as those
> Of theirs are blent in them;
> So each new man strikes root into a far fore-time."

The family tree is therefore not merely traced up for the satisfaction of family pride, but when it conveys some knowledge of the individuals whose names appear on the stem, or rather the two stems, it may possess definite scientific interest. Biography therefore naturally takes account of not only father and mother, but of the facts and even the traditions current in the family during as many generations as possible. Ramsay

is a comparatively common name in Scotland, but whether it has any relation to the Ramsey island off St. Davids or the bay in the Isle of Man must be left to the philologists. Certainly it is very widely diffused, for there are Finlanders who bear the same name and trace their descent from the same ancestry as the subject of this memoir.

Dr. Johnson is reported by Boswell to have expressed the opinion that "every man's life may be best written by himself." Whatever the reader's view may be in regard to this question the writer who undertakes the serious task of compiling a biography will naturally acknowledge an obligation when it happens that this task has already been accepted by the subject of the book, though he probably feels that the author of an autobiography can do little more than supply facts. Judgment of character and, generally, estimates concerning the life and its influence can only be truly supplied by contemporaries. Fortunately in the present case an autobiography, though a mere outline, has been left by Sir William Ramsay and furnishes a modest record down to 1912. This however is written in German, and is to be found as an introduction to Ostwald's volume of Ramsay's *Essays* under the title "Vergangenes und Künftiges aus der Chemie" (2nd edition, 1913, Leipzig: Akademische Verlags-Gesellschaft).

An interesting introductory passage in this autobiography expresses the writer's strong conviction of the all-powerful influence of heredity and refers to the

application of such considerations to his own case, pointing out that his forefathers on the paternal side were dyers for certainly seven generations, while on his mother's side they were physicians, "so that it may be safely concluded," he says, "that I had the prospect of possessing chemical instincts by way of inheritance."

His father was interested in many directions among scientific subjects. He was a good mathematician and was accustomed regularly to follow the observations and researches of his brother Sir Andrew Ramsay, Director-General of the Geological Survey and successor to Sir Roderick Murchison. These scientific tendencies were shared by the whole generation on the father's side; for the other uncle, John, became a sugar planter in Demerara, and his factory and laboratory were furnished with the newest machines and scientific apparatus connected with the manufacture and examination of sugar. The library and apparatus belonging to this Uncle John descended to the nephew. Aunt Eliza, his father's sister, was an excellent botanist and collected the local flora of many parts of Scotland.

On the mother's side the grandfather of the chemist was a physician in Edinburgh and the author of several text-books on chemistry and anatomy for the use of medical students. He died in 1835. His cousin, also named Archibald Robertson, was a Doctor of Medicine and Fellow of the Royal Society, and became known through his medical researches. Three sons of the

grandfather became physicians, but they all died comparatively young. The author of the *Autobiography* is therefore justified in his remark that "whatever chemical talent I possess is an inheritance from my ancestors on both sides" (p. 4).

The family history has already been traced by Sir Archibald Geikie in the interesting life he has given of Sir Andrew Ramsay the geologist (Macmillan, 1895), uncle of Sir William. From this volume the following introductory passage may be quoted:

"In the little town of Haddington during last century several generations of Ramsays carried on the craft of dyers. At length one of the family, William by name, the son and grandson of previous Williams who had been content to pursue their calling by the banks of the East Lothian Tyne, determined to push his fortune in a wider sphere. He appears to have been a man of high principle and great energy, wide-minded and good-tempered, with a strong bent towards chemical pursuits, and not a little originality as an investigator. About the year 1785 he went to Glasgow, and became there junior partner in the firm of Arthur and Turnbull, manufacturers of wood spirit and pyroligneous acid. Besides making dyer's chemicals and a variety of prussian blue still known as 'Turnbull's Blue,' this firm was the first to manufacture 'chloride of magnesia' as a bleaching liquor and also 'bichrome.' Had William Ramsay patented some of his processes it was generally believed among his friends that he might have become one of the richest men in the west of Scotland. But he did not consider himself entitled to retain for his own behoof a discovery which, if made widely known, would benefit the general industry of the country, and he was content to remain comparatively poor. The requirements of his business made him an excellent practical chemist, but his

interest in chemistry reached far beyond these limits. In 1800 he founded the Chemical Society of Glasgow, into which, by the energy of his example and the kindly courtesy of his manner, he brought those of his fellow-citizens who were interested in the progress of theoretical as well as practical chemistry. He was chosen first President, and among his associates were the well-remembered chemist and mineralogist Thomas Thomson, Professor of Chemistry in the Glasgow University, and Walter Crum of Thornliebank. Two years later, on the foundation of a wider brotherhood of science by the establishment of the Philosophical Society of Glasgow, the Chemical Society was voluntary dissolved. . . . William Ramsay's reputation as a chemist spread outside his own country. His house was one of the attractions to foreign chemists who came to Glasgow, and even long after his death his widow received visits from such men as Liebig, who remembered her husband's meritorious work."

There is evidence that this William Ramsay had a distinct inclination toward experimental investigation, for the *Catalogue of Scientific Papers*, compiled by the Royal Society of London, contains the titles of three papers under his name, as follows:

1. On the Solubility of some of the Earths by means of Sugar. *Nicholson's Journal*, 1807.

2. On Culinary Salt, with the means of purifying it from substances which contaminate its qualities. *Highland Society's Transactions*, 1816.

3. On the Antiseptic Power of Pyroligneous Acid. *Edinburgh Philosophical Journal*, 1820.

"In the year 1809 William Ramsay married Elizabeth Crombie, a second cousin of his own, daughter of Mr. Andrew Crombie, writer in Edinburgh. The Crombies, like the Ramsays, had for

many generations been connected with the trade of dyers. . . . Mrs. Ramsay was a woman of strongly marked character, uniting a firmness of purpose with a gentleness and sweetness of nature that gave her remarkable influence over all who came in contact with her. Clever and wise she had had her natural powers quickened and trained by an excellent education. She was beloved by the young for whom her face used to light up with a cordial welcome. In the esteem and affection of her sons she ever held the foremost place. Her husband died in 1827, and her circumstances became thereafter somewhat straitened, but her cheery spirit and unruffled temper enabled her to keep a happy, though modest home for her children. She survived till the year 1858. The children of this marriage were four in number—Eliza, born in 1810, William in 1811, Andrew Crombie in 1814, and John in 1816."

The eldest son of this family, William, was the father of Sir William Ramsay. Without such striking gifts as his father, brother (Andrew Crombie), or his famous son, William Ramsay was a man of scientific tastes and culture and of a most lovable character. At the time of his father's death this boy of sixteen virtually constituted himself the head of the family and accepted the responsibility of this post. In the natural course of events he would have been taken into the chemical works and, in time, would have succeeded his father as partner. He was offered a place as assistant under Thomas Graham at the Mechanic's Institute in Glasgow, but the well-known shipbuilder Robert Napier, a friend of his father's, having invited him to become an apprentice under him, this was regarded as offering a better prospect for the future. Here he remained five years.

In the last two years of his time he attended lectures in the University on mathematics, physics, and chemistry, William Thomson, later Lord Kelvin, being among his fellow-students. Later, as engineer, he took part in the enormous development of the railway systems then extending over the whole country. An accident to one of his eyes having made it advisable to change his occupation, he obtained the appointment of Surveyor to the Scottish Union Insurance Company, and with this company he remained connected for nearly fifty years. After his father's death he lived with his mother and tried to take a father's place to his sister and his younger brothers. It was not till he was nearly forty years of age that he felt free to marry a lady to whom he had been virtually engaged for twenty years.

At the time of the elder William Ramsay's death (1827) one of the leading physicians in Edinburgh was Dr. Archibald Robertson already referred to—a man of great charm and ability. His family consisted of five sons and two daughters. The sons were preparing for the medical profession and were very delicate, indeed only one of them lived to take up practice. The consequent anxiety and sorrow made their father neglect his affairs, and when he died, at a comparatively early age, his two daughters found themselves almost unprovided for. The elder who afterwards became the wife of Dr. Jolly, a well-known Scottish theologian, found a post as governess in Dumfriesshire, and though friends offered the younger sister, Catherine, a home,

she, with that optimism and independence of character that were afterwards to appear in her son, declined all offers of help, and she too found a situation in the family of Mr. Allan Buchanan of Glasgow, whose wife was a Miss Crombie, a niece of old Mrs. Ramsay. Allan Buchanan was the second son of George Buchanan, a Glasgow worthy of the end of the eighteenth century. His works were the first in Glasgow to employ steam power. Three of his sons were partners. The old man, to distinguish him from the many other Georges of the Buchanan family, was known as "Bonny Geordie," and a large share of his good looks seems to have gone into the family of his son Allan, as they were a strikingly handsome set of young people.

It was into this family that Miss Robertson came, at the age of eighteen, as governess, and as it turned out lifelong friend. Not only was she much beloved by her charges, but also by their cousins, a large flock of young Buchanans, and with them all ties were formed that lasted till the end. It was a daughter of one of these cousins (George the son of William Buchanan, Allan's eldest brother), who, fifty years after, became the wife of her son.

Miss Robertson was at this time a tall slight, attractive girl, with the side curls and sloping shoulders of the period, but even at that age of a very strong character and clearly defined views. She was not much older than the eldest of her young charges, but from the first made her influence felt. One is tempted to

dwell a good deal upon her personality, for it was from her that her son, the future Sir William Ramsay, inherited many of the qualities that made him what he was.

Besides the young Buchanans, Mrs. Allan Buchanan's own first cousins, the Ramsay family, came a great deal to the house, and from the first the eldest brother William and Miss Robertson were mutually attracted. Probably the similarity in their history and their circumstances, both being at an early age obliged to take up positions of authority and responsibility, drew them together, and from that time forward there seemed to be, if not an actual engagement, at least a distinct understanding that they would wait for each other. As her pupils grew up and passed beyond her care, Miss Robertson moved from family to family, always making lifelong friends, though none were ever quite so dear to her as her first charges, the Buchanan family. It was not till 1851 that circumstances permitted the announcement of a formal engagement, both of them being about forty, at that time considered a very late period to embark on the dangers of matrimony. There was much interest felt among their friends as to how such an elderly pair would fit into each other's ways, but a happier couple never lived, and the birth of their little boy in 1852 [1] was the crowning joy of their lives.

Friendly curiosity was again aroused as to how the little boy would be brought up, but anxiety might have been spared, for in spite of their devotion the parents

[1] 2nd October, at Queen's Crescent, Glasgow.

carefully refrained from spoiling their only child. He was a great deal with them, heard them talk, and insensibly copied them so that as a little boy he used rather grown up words and ways of speaking. He played quietly with his toys and carried on his child's life alongside of theirs, thinking his own thoughts and only coming out of his dreams when actually spoken to. His mother did all she could to surround him with other children, and the young MacVicars, Langs and Turnbulls, all friends of the second and third generation, were frequent visitors. Other very early boy friends were the twin McClures—whose mother was Grace Buchanan, Mrs. Ramsay's first pupil—the two Urquharts and Willie Buchanan, who afterwards became his brother-in-law. These friendships never lapsed, and though both the McClures are dead their sons are still friends of the family.

From notes supplied by Miss Flora MacVicar and Mrs. McNicol, early friends of the family, we know that young Ramsay had a very happy childhood and youth, though in some respects the circumstances surrounding his life were different from those of other boys. His father and mother were both intelligent and affectionate parents, and as Barrie says, in his *Margaret Ogilvie*, "so much of what is great in Scotland has sprung from the closeness of the family ties." He had not much liking for the games on which boys usually spend so much time. His youthful amusements had a thread of investigation running through them, and in such pursuits as rigging out toyboats or building bricks he always had

a plan of his own, though in the result he had sometimes to confess that he had been mistaken. He was fond of reading and among his favourite books were *Alice in Wonderland*, Hans Andersen's *Fairy Stories*, and later the books usually enjoyed by boys about lighthouses, fire-brigades, and other practical things. He had a strong love of animals and always had a favourite dog. From his earliest days he had considerable aptitude for music, and at a preparatory school he attended he was the quickest among the little pupils to learn reading music. In later years he was a pupil of Dr. A. L. Peace, organist of Glasgow Cathedral. He also became an accomplished "whistler," and could accompany himself on the piano. This accomplishment, it may be added, often gave pleasure to his friends in later life. It was delightful to hear a florid air like Bishop's "Should he upbraid," with all the runs and trills given with perfect clearness and accuracy. His powers as a linguist were remarkable and the readiness with which he acquired a new language served him very notably throughout life and on many public occasions attracted admiration. He used jokingly to say that the only language of which the pronunciation had baffled him was Gaelic. His natural inclination for new languages and the method early adopted for their acquisition is illustrated by the reminiscences of Mr. M. M. Pattison Muir. He says:

"I can scarcely remember the time when I did not know Ramsay. Looking back nearly sixty years, I see a small boy

seated between his parents in a pew in the front gallery of Free St. Matthew's Church in Glasgow. During the long doctrinal discourses of the minister, I used to wonder what the little boy in the next pew was doing; he seemed to be intently reading his Bible. In after years he told me he was learning French, or German. Most Scottish boys of that time, all Scottish boys brought up in a Calvinistic household—as Ramsay was—were at home in the language of the Bible. He took a French or a German Bible to church in his pocket; during the sermon he read it. To translate into English did not require the help of a dictionary; the English text was at his finger-ends. He used to say that even his mother—a strict Calvinist—could not object to her son reading his Bible in church. As he read, and translated backwards and forwards, he heard what the minister was saying. Years afterwards he often took me back to Free St. Matthew's church by repeating screeds of the sermons of the Reverend Samuel Miller. In a letter I had from Ramsay in 1913, he recalled the old days by drawing a rough sketch of the church and marking the places where various members of the flock used to sit. Unlike many scientific men, Ramsay had an excellent visualising memory. We often wondered, he and I, what the minister meant by praying that one of the Elders of the Church, a big burly man, 'might go in and out as a he-goat before the congregation.'"

Another early friend was Robert Dowie Urquhart, now an advocate in Edinburgh. He tells us that he and Willie Ramsay were together among the first pupils of a Scots-Canadian in a house in the then western-most district of Glasgow.

"Our teacher," he says, "I can visualise almost as if he were before me, and I realise that the pupils of that engaging personality with his strong features and kind eyes were beginning their school life under the best of auspices. My earliest recollections

of William Ramsay connect themselves more with the playtime than the school. In the impressions of him that remain from those playhours the figure of his mother seems peculiarly present. He was an only child and his companions were soon the friends of his mother also. I think I see her on the steps of their house, with shrubbery on either hand. I see the handsome figure with a singularly smiling restfulness of countenance. Her son had a great look of her. At the same time he was about equally like his father whom we boys knew and who had been a school friend of my father's. Mr. Ramsay I can also discern with the mind's eye. He comes before me as a very attractive genial personality, with a kindly smile always ready to light up his pleasant features.

I have dwelt thus on his father and mother because on thinking over these early impressions I have come to the conclusion that Ramsay's after-life was the outcome, to a singular degree, of his parents' mentality and of their influence."

With the exception of his Ramsay cousins in London (children of Sir Andrew), who were too far away for frequent meetings, and his mother's only nephew Archibald Jolly, son of Rev. Dr. Jolly, who was several years the elder, Ramsay was the only young member of his family circle. He managed however to have a good many of the amusements of youth, not always unconnected with mischief. He used to describe with great glee the beginning of his friendship with the Purdie-Dickson family, a solemn interview with the learned professor on the subject of a broken study window and a catapult which was confiscated on the spot. As he never heard of it being used by its new owner, he always felt this a great waste. There was also a tale of a small brass cannon, which, though

packed hard with gunpowder, would not go off, and was, with much indignation, thrown into the kitchen fire with results that were rather startling but fortunately did no harm beyond a hole in an opposite neighbour's dining-room wall.

As Mr. Ramsay could not take long summer holidays, Mrs. Ramsay used to take her son to visit her relations and friends for a great part of his vacations. As these were scattered over a great part of Scotland, young Ramsay had, from a very early age, a wide knowledge of his native land. Mrs. Ramsay's only surviving brother, who had been an army doctor, had settled at Strathmiglo in Fife. He seems to have been rather eccentric and something of a woman hater. He paid his professional visits on horseback and taught his young nephew to ride, also the rudiments of golf. At Strathmiglo he had the good luck to have the companionship of the "children of the manse," the family of the Rev. Dr. Macara, with whom he spent much of his time. This friendship was never allowed to drop, and the last year of his life he was closely associated with Sir Charles Macara, the eldest of the "Macara boys," in his crusade against the importation of cotton into Germany. Other holidays were spent with his mother's only sister Mrs. Jolly, the wife of the minister of Bowden, in the border country. Their nearest neighbours were the Bruntons, and there at a very early age he made the acquaintance of "Tommy Lauder Brunton." The exact form of introduction is not

William Ramsay with his Father and Mother about 1860.

quite clear. One party put out his tongue and the other threw a stone, but which did which and who began hostilities, has always been doubtful. Fifty years after, Sir William Ramsay, as his oldest friend present, proposed the health of Sir Lauder Brunton at a public dinner, and began by saying that he remembered, as far back as he could recall anything, playing and quarrelling with that "big, rough boy, Tommy Brunton!" To an audience, familiar with the delicate frame, the clear cut features, and the chivalrous courtesy of that beloved physician, the description was too delightful, and the laughter was so hearty and so long that it was with difficulty that the speaker could proceed.

Dr. Jolly's son became minister in Shetland, and there young Ramsay spent holidays, sometimes with his mother, and sometimes accompanied by a friend of his own age. There he learned to swim and to manage a boat in all weathers. As minister of a scattered parish Mr. Jolly had to go from one island to another, and though to him it must have been irksome and difficult, to the boys who went with him it was a time of adventure and delight. They used to arrive cold and drenched and be welcomed at the farms and made much of. Sometimes they had strange fare. Once they had cormorant, which besides being very tough had "an ancient and fish-like smell." Its state was apologised for, it having been buried only for a week, whereas the proper period should have been a fortnight or three weeks!

The liveliest of all his visits were those to the Turnbull family at the place of Bonhill. A branch of the Turnbulls' works had been started on the Water of Leven, and the old manor-house was the home of the Turnbull family. It was a curious old house, the property of the Smolletts. It was really two complete houses, at right angles, touching each other but with no passage between. Two sons of the old Mr. Turnbull, old Mr. Ramsay's partner, lived in one house and the widow of their brother in the other. The establishments were separate, but there was constant communication, and one would imagine mutual criticism. The old people took the greatest interest in all that went on in the other house, where Mrs. Turnbull lived, with her large family of sons and one beautiful and charming daughter, afterwards Mrs. Duncan Jameson. They were all high spirited, witty and kind hearted, and the hospitality of the house was unbounded. Formal invitations were quite unnecessary, and however many friends offered themselves, there was always room and a warm welcome. We have the testimony of Mr. William Turnbull (grandson of the Turnbull who with Sir William Ramsay's grandfather constituted the firm of Turnbull & Ramsay) that young William Ramsay was a very popular visitor at Bonhill. He writes as follows:

"Being an excellent raconteur and very musical, he afforded us all much amusement. He was wiry and athletic, a good pedestrian, rower, and one of the best swimmers I ever met. Even in those days he occupied his idle moments in working out

chemical problems, or in devising new chemical apparatus at which he was particularly expert—being very neat handed.

When, owing to deaths in our family, I was obliged to give up my farm in the Highlands, in order to carry on our wood distilling business in various parts of the country, I remember with gratitude how much he helped me by his advice and chemical knowledge. He suggested several improvements in our plant, which proved of considerable advantage."

It was when staying at Bonhill that Ramsay came to know Loch-Lomond side so well, and picked up many stories with which he used to regale his friends. It was an old gardener at Bonhill who complained that an old gate was fair off its "equileebrum and sair corroberated."

About 1901, he was asked by Miss Duncan Jameson, now Mrs. John Baird Smith, to write something in her album. He wrote lines after the fashion of Longfellow's *Hiawatha*, of which the following is a sufficient sample :

> "Of your 'weird,' 'quaint,' 'splendid' friendship,
> Which has lasted generations,
> Ever since your greatgrandfather,
> And my father's father sauntered,
> On the green banks of the Leven,
> Talking over current prices
> Of the pyrolignous acid,
> And the products of the beech-tree,
> Of the oak and of the alder
> Heated up to fiery redness
> In the ovens of Camlachie.
> May the pinions of that friendship
> Never moult a single feather,
> But continue through the ages
> Unto countless generations."

Mr. Ramsay's only sister, who had at a rather advanced age married Mr. Robert Dymock of Edinburgh, had a house at Kilcreggan at the mouth of Loch Long, and there the Ramsays spent much of their time in summer. There Ramsay had a boat, and in it he made long excursions alone or with friends. His friends the MacVicars, lived for many years at the head of Loch Goil, a very beautiful loch that branches out of Loch Long, and he used to arrive there, having rowed all the way, something like 18 miles, and often with a rough sea on. Telegraph offices were sparsely distributed in those parts, and there was no way of announcing his safe arrival, but his mother never worried. Oddly enough she was much more anxious about climbing risks than boating ones, and when he first went to Switzerland she was in terror all the time; whereas in the worst of weathers, she was never anxious about him in his boat.

Belmont, as the Kilcreggan house was called, passed to his parents, and afterwards to himself, and remained in his possession till 1898. During that time it was the scene of many happy gatherings not only of his early but also of his later friends. Fitzgerald, Remsen, Ostwald, the Massons—father and son—Sydney Young and Sir John Murray were among the many who stayed there, but this belongs to a later part of the story.

In due time Willie Ramsay entered the Glasgow Academy, and of his life at this period we get some glimpses with the aid of a life-long friend, Mr. H. B.

Fyfe, who has supplied the following notes of his recol lections :

"I met William Ramsay for the first time in August 1863 when we both joined the Third Latin Class of the Glasgow Academy. He and I and William Miller, nephew of the late Dr. Samuel Miller, sat together at the foot of the class for two or three days till the class was arranged in Divisions, and I have a very vivid recollection of him at that time. He continued in the Glasgow Academy till May 1866, taking the Third Latin in 63/64, the Fourth Latin 64/65 and the Fifth Latin 65/66.

So far as I remember he did not take any part in the class games, and I do not remember that he took any prizes. I think this was accounted for by the fact that he was nearly two years junior to the average age of the class. There were about 60 boys in the Third Latin and it was divided into two divisions according to seniority. The senior division was considerably larger than the junior, and except Alexander MacEwen they were all boys who had been born before the end of January 1851. As Ramsay was not born till October 1852 he must have been about two years below the average in age. He was all the same about the average height.

In November 1866 he went to the University and took the usual Arts Degree curriculum. This would be, I think, Latin and Greek for two years, that is till May 1868, Logic and Mathematics in 1868/69, and Natural Philosophy and Moral Philosophy in 69/70. I do not think he ever took chemistry in the University.

Our friendship began shortly after we went to College. I was attending the Junior Latin Class with him, beginning in November 1866, and in addition I took the class of chemistry beginning in October 1866 under Professor Anderson. I remember that one day passing through the Quadrangle I heard Ramsay talking to some students of an experiment which he was going to carry through. I joined them and told him that I was attending the

chemistry class and that what he was proposing would be dangerous. Next morning he called for me when I was at breakfast about half-past seven, on his way down to College. He said he had read up about what I had said and I was quite right, and we walked down to College together. After that he called for me every morning on the way down. The class began at 8 a.m. and he walked all the way from Ashton Terrace to the High Street, which must be nearly three miles.

At that time he knew nothing of chemistry theoretically, but he had for some time been working at home at various experiments as we called them. He worked in his bedroom, and there were a great many bottles always about, containing acids, salts, mercury, and so on. When we began to meet in this way, I found he was quite familiar with all the ways of getting the material and apparatus for working in chemistry. We used to meet at my house in the afternoons and do what practical work we could, making oxygen and hydrogen and various simple compounds such as oxalic acid from sugar. We also worked a good deal with glass. We used to go to Spencer's shop in Union Street, and also to White's, the optician's, and buy flasks, retorts, crucibles, spirit lamps and so on, and also materials like zinc filings for making hydrogen, sulphuric and nitric acids, etc. We never got the length of any real analysis, but became quite expert at the things we did, which were usually repetitions of the demonstrations given in the class or described in books.

There were a number of old chemistry books in his house.[1] I do not know whom they belonged to originally, but they were a good deal out of date. Just before that time there had been considerable changes in chemistry, particularly in the nomenclature, and spectrum analysis had just been introduced. I remember one book in particular was Faraday's *Manipulation.* This was a most useful book, and it had been a great stand-by

[1] These probably came, at least in part, from the library of the uncle John, the sugar planter in Demerara.

with him. He lent it to me about this time. We used to work with mouth blow-pipes and Bunsen gas-burners which we made ourselves, and in this way he became exceedingly expert in working with glass. I think he found this practice very useful in after-life. We made nearly all the apparatus we used except flasks, retorts and beakers.

After this session we were very close friends, and I think every summer after that I visited his people, besides meeting very often at our houses and walking together on the Saturdays. I did very little chemistry with him after the summer of 1867, but he continued his home work in the following year, 67/68, while he was attending the Latin and Greek classes. He had no liking for either Latin or Greek and was not much interested in his College work. Perhaps he spent too much time over his scientific pursuits. At that time it was not chemistry alone, for he was also much interested in geology, and in our walks he was constantly pointing out interesting things such as ice marks on the boulders at Arran and evidences of change of level in the ground.

He did not begin to study chemistry systematically till about October 1869, when he went to Mr. Tatlock's laboratory in the afternoons, after his College classes for the day were over, and began to work under him. I do not know how long he continued there, but I think he must have kept up this kind of practical work till he left College. In addition to his College classes and chemistry he took lessons in music under Dr. Peace, and also in French and German, the German being under Dr. Schlomka.

It was in 1869 that he first went to Shetland to stay with his cousin Mr. Jolly at Walls, and while he was there we first began to correspond, and kept up our correspondence more or less from that time till the end. On the following winter, 69/70, my eyesight failed and for nearly a year I was unable to read. During that time he was exceedingly kind to me in coming to read to me and also in arranging for walks in the country. He must

by that time have acquired considerable familiarity with languages, for he read a good deal of Béranger and other French poets. I was not able to understand fully, but that did not make much difference as he was always willing to translate. He was also at the same time trying to learn Gaelic and used to amuse us a good deal by going down to the kitchen to test his progress and to ask questions from a Highland cook they had. In the summer of 1870, when I was in the first year of my apprenticeship, I went with him to Shetland. His father and mother went also and we stayed at Walls most of the time. I was away three weeks, but they stayed on for a considerable time longer. When we started, about the end of June, there was no thought of war, but when he and I walked into Lerwick after my holidays had expired, we found that war had already broken out between Germany and France. No hint had reached us at Walls.

When he came back from Germany he had made a great advance in every way. Before that he was much of a boy, but afterwards he had made greater progress than any of us who had remained at home. Very soon he became Assistant in the Chemistry Department of Anderson's College, and I think was also Assistant in Technical Chemistry there. He must have been in this position for about two years. He did not do any lecturing, but he worked in the laboratory and acted as Tutorial Assistant. During that time we were constantly meeting and took several short trips together in the summers. Somewhere about 1874 we went to Ireland together, meeting one morning in Dublin and going across by train to Galway. From Galway we started on a walking tour through Clare, coming back by rail from Limerick to Dublin. In 1876 we went to Paris together with Guthrie Smith and Charles MacLean and spent about ten days there, and afterwards we went to Normandy, taking the steamer from Havre to Caen. From Caen Guthrie Smith, MacLean and I came home, but Ramsay stayed on. One of the scientific institutions of France, the Association Française pour l'Avancement des Sciences, was

about to hold a meeting at Havre, and Ramsay waited on about three weeks to attend it. He was preparing a paper on the research work he had done in Germany, and when he went to the meeting he delivered his address in French and was very highly complimented. This, I think, was the beginning of his acquaintance with the notable scientific men of France, which he kept up ever afterwards. I think it was about this same year that he became Assistant to the Professor of Chemistry in Glasgow University, a post which he held until he was appointed Professor at Bristol about 1880. After that came his marriage. Even after that we made several holiday trips together from time to time. In 1887 we made a bicycle tour through England for about a fortnight and had many interesting experiences. We also had one later, round the south of Scotland, and another time we took our cycles to Penzance and bicycled back most of the way to London. Before these excursions we had a short tour up the west coast of Scotland and round by Loch Maree. We also had a trip to Rio de Janeiro in the Royal Mail, in, I think, 1905.

Of course I met Ramsay's father and mother very frequently and stayed with them often. I think Ramsay took his scientific bias from his father, who was greatly interested in every scientific subject, and glad to talk about them. Geology was his favorite and it was a constant subject of conversation. Every scientific question, such as Darwinism, was readily and frequently discussed between father and son. His father very often came long walks with us, particularly during the stay in Shetland in 1870, and afterwards at Kilcreggan. When I saw him first he was suffering from an injury to his eye, and at that time he and Mrs. Ramsay came to the Glasgow Academy twice to see the class. It was such an unusual incident that I remember it very well. I think he also took his sociable disposition and broad outlook on life a good deal from his father. His mother was a very notable woman. She had very strong views on all matters

connected with religion and the Church, and I think she looked with considerable suspicion on scientific enquiries. She did not oppose or argue about such enquiries, but she certainly did not encourage talk about such subjects as Darwinism, and was immediately up in arms if anything was said that seemed to question orthodox religious views. I think it must have been owing to her that so much of Ramsay's education was devoted to such subjects as Latin and Greek and Philosophy, in which he never took any particular interest. She had splendidly calm nerves and a clear logical head, both of which qualities she passed on to her son.

It has been said that he was a dreamy lad in school.[1] He certainly was not attentive, but I do not think he was dreamy in the ordinary sense at all. He certainly was not given to reverie. His own explanation was that he could not bring himself to take an interest in the subjects that were taught, particularly Latin and Greek and more particularly the way in which they were taught, and he professed to be thinking about other things when we were worrying over Latin syntax. I remember his telling me that during the sermons in Saint Matthew's, he thought he had worked out a good many of the propositions of Euclid by putting together the lozenge panes in the windows and seeing how they could work out into different models. He certainly was not attentive in Church either, but anyone who heard his imitations of Davidson of Arran must have been convinced that he could attend to some purpose when he had a mind to.

When he came back from Germany he was splendidly equipped both mentally and physically for a successful career. He had perfect health. He could walk 40 miles in a day without any difficulty. He was a very strong and graceful swimmer and could dive further than any amateur I have seen. When we

[1] He describes himself in his autobiography as "to a certain extent precocious, though idle and dreamy youngster" (p. 5).

were in Paris in 1876 the four of us used to go to one of the baths in the Seine every forenoon, and after the first time, when Ramsay was ready to dive, the bathman would pass round the word that the Englishman was going to dive and everyone in the establishment, including the washerwoman outside, would crowd in and take up positions to watch him. He dived the whole length of the bath and sometimes turned there under water and came back a part of the length. He had absolute control of his nerves and hardly ever showed excitement or embarrassment. He had great vitality and also the advantage of being an excellent sleeper all through his life.

With these physical qualities he had also great courage and tenacity. He never seemed to be upset by anything. All the little difficulties which usually turn men back never seemed to make the slightest impression upon him. His enormous vitality enabled him to take up strenuous work of any kind at any time and he never seemed to tire. After a session at College he would look run down, but after two days on holiday he would be as strong as ever and as ready to undertake a full day's work.

I always found him exceedingly kind-hearted and considerate. I do not think anyone who needed friendliness or consideration would ever have been passed by by him, and for my own part, especially at the time when my eyesight failed me, he was kindness itself."

His college career cannot be said to have been brilliant—partly because he was younger than most of his fellow-students, and partly that the subjects chosen for his study were, for the most part, not those in which he was chiefly interested. The one great desire of his mother's heart was that he should go into the Church; and though she never pressed this upon him, it seems almost certain that the subjects chosen for his first year's work were selected with that aim in view. His great love of

learning languages did not extend to the dead languages as taught in school or college, and he seems to have passed through these classes with but little distinction. To him the pleasantest memories of his college life were of the friendships made there.

It is not possible to write of all those friends: "Some with lives that came to nothing, Some with deeds as well undone," mostly all scattered now and many dead; but there are a few names that stand out. Henry Fyfe, a well-known Glasgow lawyer, already quoted, was both a school and a college friend. So was also "Alec MacEwen," later more widely known as the Rev. Professor MacEwen, scholar, theologian and ardent worker for the gathering into one of the many divisions of the Church in Scotland. His work was cut short by death a few months after his friend Ramsay. There was also George Wardlaw Burnet, an Edinburgh advocate and one of the brilliant wits of the "Parliament House" of his day. His parodies and other verses are too personal and of interest too purely local to be quoted here. Ramsay received the news of his death at Port Said on his way home from India, just after posting him a long letter telling him all about the tour.

There was another of the friends whom they all looked on as the greatest of them all. John Struthers was a man hardly known out of Scotland and there only to a restricted public. He was a minister of the "Reformed Presbyterian Church," of which Butler said all Scots

were grim, but none so grim as they. Though he held these views he held them with a wide charity, and he had the gift of a strong sense of humour which rounded off all angles. A more absolutely sincere person it would be impossible to meet, and he was at the same time the most humble-minded of men. In 1895 Glasgow University conferred, or rather it was announced in the papers that it was conferring on him the degree of Doctor of Divinity. It was at once respectfully declined. He said to his friend Ramsay: "How could I have taken it when so many better men are passed over?" It used to surprise his friends that a man of his gifts should have belonged to such a very small sect, but nothing would have made him change it; his faith was greater than his creed and his heart than either. Ramsay never felt a holiday in Scotland complete without a sight of his friend, though it was difficult to get him away from his manse even for a night. "You never know who might want you," he used to say. Though their walks in life were so very different his friendship was one of the most precious in Ramsay's life, and his sudden death in 1915 a very great sorrow.

CHAPTER II

AT THE UNIVERSITY

RAMSAY's acquaintance with chemistry began early, as narrated in Mr. Fyfe's account of his recollections. The autobiography tells us that before he left school he had the misfortune to break a leg at football. During his convalescence he read Graham's *Chemistry* with the object chiefly, as he confesses, of finding out how to make fireworks. His father supplied him with small quantities of potassium chlorate, phosphorus, sulphuric acid, etc., together with small beakers, flasks, and a spirit lamp, wherewith he amused himself during the tedious months of enforced idleness. It is a little difficult to imagine how such materials could be safely handled while the operator was in a recumbent position, but as no accidents are recorded we are left to suppose that all went well. In Tatlock's laboratory a year was devoted exclusively to analytical work, both qualitative and quantitative. One of the assistants having fallen ill, Ramsay was temporarily promoted to replace him. Here he received his first idea of responsibility. The following year he attended the lectures of Professor Thomas Anderson, known for his researches on the

pyridine and quinoline bases. In consequence of the failure of Anderson's health the lectures were continued by John Ferguson, his assistant, who afterwards became his successor.[1] About this time Ramsay also attended the class in anatomy of Professor Allen Thomson, whom he describes as one of the best lecturers he ever heard. His time was, however, chiefly occupied with chemistry and mathematics. While still in Tatlock's laboratory he began attendance on Sir William Thomson's (Lord Kelvin) lectures, as well as hearing the lectures in geology by Professor John Young. He also began to work in Thomson's laboratory, which occupied a cellar in the old college buildings. Here he relates that his first exercise consisted in getting the "kinks" out of a bundle of copper wire, a task which occupied a week. He was then placed before a quadrant electrometer and required to study its construction and use, and afterwards to determine the potential differences between all sorts of surfaces charged or uncharged. Thomson was a most stimulating and inspiring teacher notwithstanding the eccentricities of his lectures, which were chiefly over the heads of his students, and the unusual methods of instruction in the laboratory. Ramsay has given in his essay "Lord Kelvin" a most interesting account of his work and career and a warm expression of his own indebtedness to the teaching and example of his great fellow-countryman.

[1] Professor Ferguson died 2nd November, 1916, soon after retirement from the Chair.

During these years and throughout life he kept up a correspondence with his cousin, Ella Ramsay (eldest daughter of Professor Andrew Ramsay). In one of these letters (4th September, 1869) he conveys an invitation to his cousins to come to the wedding of his Aunt Eliza. In the course of it he remarks: "I think it is six years since we met last at Beaumaris. I have no doubt we have both changed unspeakably." On 24th March, 1870, he writes as follows to his cousin:

"I may as well tell you at once that I have become a dangerous character. In fact, I have without putting off this mortal coil, put on a mortal ugly uniform. In other words, as Dr. Young says when he wants to make a very complicated phrase still more complicated, I have joined the volunteers, and may be seen any Monday, Wednesday and Friday from 8 to 9 p.m. right facing, etc."

In another letter, dated 21st June, 1870, he describes the journey of the whole family and "my most intimate friend Fyfe" to Shetland, calling at Kirkwall on the way. Shooting, fishing, pony-riding and boating occupied the boys, and W. R. reports to his cousin that he has "got that book of Bach's, and can play most of the pieces. They are extremely difficult. The Gigue and the Gavotte and Musette are very pretty. I have been going in for Mendelssohn's Songs without Words and have learned four of them."

On returning from this holiday Ramsay and his mother heard of the war between France and Germany. He had intended to go to Heidelberg to work under

Bunsen. It was, however, deemed prudent to defer carrying this intention into effect for a time, and he therefore remained in Tatlock's laboratory and continued attendance on Thomson's lectures. As soon as the victory of the Germans became obvious he proceeded to Heidelberg, called on Bunsen, and secured a place in his laboratory. As, however, many of his friends recommended strongly Fittig's laboratory at Tübingen, he proceeded there in the spring of 1871, and resumed the work on platinammonium bases which he had been carrying on in Tatlock's laboratory. A number of letters to his father and mother, addressed from Tübingen, have happily been preserved, and they give quite vivid pictures of his life in the University.

The letter, dated 7th April, 1871, shows that he stayed in London at his uncle's house (Sir Andrew's), 29 Upper Phillimore Place, on his way to Tübingen. He begins by saying "I have got the passport all right," but it does not appear when he was to start for the continent. It was Easter, and he probably remained at his uncle's for a few days. The next letter is dated 8th May, Tübingen. Evidently he had got seriously to work, as he says: "I had two explosions to-day." This apparently had something to do with the preparation or use of phosphonium iodide, which is mentioned. He says further:

"I go regularly to Fittig's lecture at 8. He lectures very distinctly and clearly. It is really very beautiful to see the way the organic compounds are arranged. . . . Dr. Remsen, the

assistant in the laboratory here, is very obliging and pleasant. He is an American. If I am here in winter, I must board with some family, for it is very difficult to pick up any German, living in lodgings."

This intention was carried out later. David King, Sir William Thomson's nephew, arriving in Tübingen at this time, Ramsay reports on 22nd May that he has to-day just succeeded in getting him housed with a German professor's family. His own letters are henceforward dated "Auf dem Graben," so he also was similarly housed (though whether under the same roof as his friend David King does not appear), for this was the house of Professor Kommerell. This unfortunate man was taken ill suddenly in January 1872, and after some weeks died. This was a distressing experience for the young boarder and in a letter to his mother he expresses his sympathy and admiration both for the widow—"the best specimen of a woman I have ever seen"—and the deceased professor, of whom he says:

"I have scarcely ever seen so good a father and pleasant and upright a man. He was about the only man in Tübingen about whom no evil was gossiped. I am just beginning to realise that he is gone. I sat up with the corpse one night and it was rather eerie work. However I did it willingly, as the others had been up the whole night before round his bedside."

As the winter came round, there are many references to the cold and the skating. He has to assure his mother that if the Neckar is frozen over, there is no part within their reach deep enough to provide danger. He also

seems to have enjoyed very much the American game of base-ball, and became a member of the club. He was intimate with several American students and with Dr. Remsen, the assistant (afterwards the well-known professor), with whom he kept up a friendly correspondence to the end of his life. His chemical studies in 1871-2 evidently did not occupy him exclusively, for beside his constant practice of German, to which there are several references in the letters, he studied Italian with a lady, always spoken of as the Gräfin, who appears to have lost her husband toward the end of the year. He also joined some of his (American ?) friends in arranging to get dancing lessons once a week on Thursday afternoons, "when we have nothing else to do. It will probably be great fun and costs almost nothing here." He also mentions that he speaks French "a good deal with the Ma'mselle. She speaks very fluently, though not with a very good accent." Then he goes on to say:

> "Papa speaks of your possibly coming out in June or July. Do rub up a little German so as to be able to converse with the Frau. I'm quite sure that you could get up enough to make yourself understood in a month or two. It is so stupid to be with people and not able to say a word. Be able to say der, die, das, etc., and know about fifty words. There will be only three left of us English-speaking people in summer."

This free and easy method of learning to speak German was of course suggested by his own linguistic readiness, but to others who have struggled all their lives with

this fearful language the process is longer and more difficult. But even Ramsay, after referring to genders and cases, admits, after nearly a year in the country (March 1872), that he is not making as much progress as he would wish, and remarks that "it is fearfully difficult for a foreigner to speak quite correctly, especially on subjects he does not know much about." It will be remembered that his mother was a strict Calvinist and apparently she had been disturbed by hearing that her son had been playing billiards. He therefore tried to reassure her in a letter bearing no date, but written probably in the middle of February 1872. He writes:

"You speak of our playing at billiards in your first sentence. There is no harm in playing the game, in fact it is the most beautiful game to be seen, and second the people who keep the billiard rooms (there really are no billiard rooms but just belong to a Wirthshaus) are most respectable people, and third the old gentleman of the establishment is, so to speak, Professor of Billiards (or Ballmeister) to the University. Fourthly, none but the most respectable students go there. Fifthly, we never waste time at it, but only take it as a relaxation when we want a little exercise to supply the deficiency of baseball in summer. Sixthly, we never bet, but he pays who loses. Seventhly, the pay is by no means high; and if those aren't reasons enough, I don't despair of convincing you at home. It's all very well talking, but what can a fellow do when he has not a piano to play (I haven't played an hour since Jany. 3rd), no walks to take, no game, no books to read, no fire in your room, and a morbid dislike to sitting down in a Wirthshaus to drink beer and an hour to wait? Answer me that, my dear Mama, and see if you wouldn't do the same yourself."

The question seems to have been renewed, and was disposed of in a letter a little later by the assurance that

"I have no intention of playing billiards at home, but in Germany it is something quite different. The billiard-room keeper is one of the most respectable persons in Tübingen and holds the rank of university teacher. There is also a university teacher of dancing and of fencing who stand on the same level as he."

Having on 8th January announced to his mother his intention of rushing home for a month as soon as the Semester is over, on 6th March, 1872, he writes to his father that he proposes to start from Tübingen on Wednesday evening 13th, proceeding homeward by way of London. As on his way out, he again stayed in the house of his uncle at Kensington. As time went on in his life at Tübingen, Ramsay seems to have felt the increasing pressure of his work, for on 14th June, 1872, he writes as follows to his father:

"You appear to think I don't like chemistry so much as I used to. It is quite a mistake. I only object, as I always do, to too much work. I was up this morning, for example, at 5.30 and studied and took my breakfast from 6 to 7,—a class from 7 to 8, one from 8 to 9, from 9 to 3 laboratory (I lunch now to have more time for work, and don't dine till 6), and from 3 to 5 I studied, then from 5 to 6 lecture, and then I dined. And now at 8 I must start again. It is simply all work and no play, except on Thursday afternoons, but Thursday evenings I work as hard as ever."

Obviously such working hours could not be sustained continuously, but what was the rule for a student in a

German university may well be commended to the notice of those students in English colleges who find difficulty in assembling in a lecture room before ten o'clock in the morning.

But the shadow of the approaching examination was over Ramsay and his fellow-students at this time, and on 26th June he tells his father that even the base-ball club has broken up, "as almost all the members are bound on hard study." On 21st July he wrote that "the Exam. is now past I am happy to say." To those who are unacquainted with the method of conducting examinations in a German university at that time it may be interesting to read his account of the process as given in the same letter:

"On Monday at 7 it began and lasted till half-past 12; then in the afternoon from 3 till 8, so we had a good spell of it. Southworth and I were in together. We went to the Pedells and were shown the questions. They were in chemistry:

The resemblances and differences between the compounds of carbon and silicium, and

The relations between glycerine and its newer derivatives and the other compounds containing three atoms carbon.

And in physics:

The different methods for determining the specific gravity of gases and vapours.

The phenomena which may be observed in crystals in polarised light.

I managed to answer the first perfectly, the second, however, not so well, and the two questions in physics pretty well.

Then to-night we had the oral exam. The five professors who compose the faculty were there. Fittig gave some very difficult

questions. Reusch (Physics), on the other hand, very easy ones. He is a very nice old fellow and appeared only to wish to make the thing as informal and easy as poss. for us. Fittig, however, put on as grave a face as poss. and shoved in his questions unmercifully. I had only to reply 'Ich weiss nicht' (I don't know) once. We had to dress up and put on white kids, and I had to get a 'tile' especially for the occasion. Then we were sent out after the exam. for about 5 minutes and were then called in and formally told that we had passed."

This examination had to be followed by the dissertation which led to the Ph.D. degree. The title-page of the dissertation, which is in English, is here reproduced :

INVESTIGATIONS

ON THE

TOLUIC AND NITROTOLUIC ACIDS

INAUGURAL DISSERTATION

FOR THE ATTAINMENT

OF THE

DEGREE OF DOCTOR OF NATURAL SCIENCES

AT THE

UNIVERSITY OF TÜBINGEN

UNDER THE PRESIDENCY

OF

DR. RUDOLF FITTIG

PROFESSOR IN ORDINARY OF CHEMISTRY

PRESENTED

BY

WILLIAM RAMSAY, JUNR.

OF GLASGOW

TÜBINGEN 1872

PRINTED BY L. R. FEUS.

On the flyleaf following is the following note, which is

not in the present case accompanied by the usual dedication to parents or friends :

"In presenting this Dissertation to a highly-distinguished Faculty as candidate for the degree of Doctor of Natural Sciences, I take the opportunity of conveying my thanks to Professor Fittig for having suggested the subject and assisted in the work described in this paper and for his great kindness to me during my stay at the University of Tübingen."

The *Autobiography* records his obligations, not only to the professor, but to Wilhelm Städel and Ira Remsen, his assistants, as well as to fellow-students Peter Römer, Emil Kachel, Böttinger and Rügheimer. Professor Remsen has supplied the following short account of the days at Tübingen. In the accompanying letter to Lady Ramsay he adds :

"After all it must be remembered that your husband was a boy at that time—only 18 when he came to Tübingen—and I was not far removed from boyhood, so that the things I recall of those days are the things that interest boys for the most part. We were at the beginning of our lives with hopes, with aspirations, with some anxiety for the future, with doubts, and yet I do not remember that we ever discussed such matters. I am thankful for the fact that the lives of our group of English-speaking students were wholesome. They were not goody-goody as a rule, but they were not in any sense bad. They were healthy boys with lots to learn and a strong desire to learn.

TÜBINGEN DAYS

In looking over recently some letters from my old friend, Ramsay, I came upon one dated March 23rd, 1904, that began with these words : 'Who would have thought when you opened

the big, front door of the Tübingen laboratory in 1871 and in answer to my question in questionable German—" Können Sie sagen wo ist die Vorlesungszimmer ? " you replied after a pause—" Oh, I guess you want the lecture-room,"—that I should now write after 33 years to tell you—.' This was one of his favorite stories. I have heard him tell it in public and I have read it in print. That is the way we first met, now 46 years ago. That was the beginning of a life-long friendship. We met perhaps a half dozen times in all these years, but we kept up a fairly active correspondence until the last. I am now asked to give a little account of the Tübingen days.

In 1870, Fittig, with whom I had worked at Göttingen, was called to Tübingen to succeed Strecker. He invited me to go with him and to serve as one of his assistants. I accepted, and so it came about that I was holding a minor place in the chemical laboratory when Ramsay arrived. It has always been a source of satisfaction to me that it was I who opened the 'big front door' for him. This fact gives me a feeling that I have been of some service to chemistry. I remained in Tübingen until the spring of 1872, so that our association was only for one year. He came up for examination for the doctor's degree a year later, but of this second year I know little and that is only hearsay.

Ramsay began in the laboratory by working on a problem which had been suggested to him by Tatlock at Glasgow, but he soon put himself wholly under Fittig's direction. At that time Fittig was still much interested in the aromatic compounds which had given him his first success, and it is not surprising that he should have proposed an investigation dealing with compounds in this field. This had to do with the toluic acids. The results furnished the basis for the dissertation which Ramsay presented to the faculty in 1872.

In the laboratory I had little to do with him, but out of the laboratory our relations were intimate. I remember that a little group of Englishmen, Scotchmen and Americans then

studying chemistry in Tübingen asked me to form a coaching class with the object of helping them in their preparation for the doctor's examination. This I did, and the class met in my room. Ramsay was one of the members of that class. When we were last together, in 1912, he reminded me of those meetings, and told me that he still preserved the essays he had prepared as part of the regular work I had exacted. In a jocose way he always referred to me as one of his teachers, and I must confess that this has given me considerable satisfaction notwithstanding the slenderness of the basis.

He was the youngest of our little party and was a great favorite. One of our forms of recreation was base-ball. It so happened that the Americans were in the majority, which accounts for the choice of this particular game. The Englishmen and Scotchmen took kindly to the game and some of them became fairly good players according to the standards of those days. When in 1912 the Johns Hopkins University conferred the honorary degree of Doctor of Laws upon Sir William it fell to my lot as President of the University to make a few remarks, and he replied. Neither of us could refrain from referring to our Tübingen days, and the base-ball club was recalled in public by Sir William. Among other things, he said: 'I tell you the Tübingen base-ball club was not to be sneezed at.' In this connection it is interesting to recall that the present Lord Milner was at times a member of the club. He was not in the University, but came to Tübingen to spend some of his vacations and while there he was invited to join us. As a rule the German students showed no skill in the game. Some of them liked to watch us, but, as far as I can remember, only one ever actually took part in a game and he did not show any aptitude for that kind of activity.

Skating was another form of recreation which was very popular with us. In this Ramsay was an adept. On many a winter afternoon we were together on the artificial lake provided for the purpose. This was conveniently situated, so that it was an

easy matter to take advantage of a few free hours to indulge in this delightful sport. The old and young of Tübingen, professors and students, and the younger ladies took part, and, as I think back, those seem to have been days of unadulterated joy.

Occasionally we came together of an evening for a dinner or something of that sort, though not often, for the evenings were mostly given up to study. One dinner I recall very clearly. I think the host was Städel, who was then privatdocent in chemistry. The fact that stands out most prominently in my memory is that Ramsay sang for us that time-honored song, 'A fine old English gentleman,' much to our satisfaction. He accompanied himself on the piano too. Those who have known him well in later life know that singing was a pleasure to him and that he was apt to burst into song upon slight provocation. This was a symptom of the happy disposition of which he was the possessor. We all felt it, and I am sure we were all helped by it unconsciously. I cannot refrain from quoting the last words of the last letter he ever wrote me, dated March 15th, 1916: 'Well, I am tired, and must stop. I look back on my long friendship with you as a very happy episode in a very happy life; for my life has been a very happy one.' "

Letters to his cousin Ella show that he was back in Glasgow in the autumn of 1872. He had obtained the post of assistant to the Young Professor of Technical Chemistry in Anderson's College, Glasgow, and on 13th November he informed his cousin that Mr. James Young was written to about the course of lectures he was to have given:

"His answer came to-day short and bitter. I do not consider that organic chemistry has anything to do with technical chemistry, and I consider it would be interference with the courses of the other professors."

So this idea had to be given up.

The professor at that time was Gustav Bischof, son of the well-known geologist. The professor's knowledge of English was very imperfect and the instruction of the few laboratory students was left to Ramsay. Otto Hehner, now one of the best known public analysts in London, was the professor's private assistant and a close intimacy soon sprang up between the two young men. Ramsay acknowledges his obligation to Hehner's advice. The latter had been a student under Fresenius and was an excellent analyst. On the other hand, in a sympathetic and interesting obituary contributed to the pages of the *Analyst* in November 1916 by Mr. Hehner the following passage shows a pleasant picture o family life and hospitable friendliness toward the young foreigner :

"His kindly silent father and his most gentle and saintly mother who showed me innumerable acts of kindness while had upon me the homesickness of a youngster, who prior to hi emigration to Scotland had never left the parental house, I hol in affectionate and reverent memory.

I spent many evenings at their home, where William enlivene the company with songs, which in later years were greeted wit enthusiastic applause by his students at social evenings of th University College Students' Club—'Marlbrouk s'en va-t-e guerre,' and such like. He had a very good voice, played hi own accompaniment and was an expert whistler. He spok German fluently, with occasional comic lapses which I endeavoure to correct in return for services rendered to me by his rougl hewing my efforts in English. . . .

William Ramsay soon became my intimate friend. We wei both full of enthusiasm, and as neither of us could obtain advic

or stimulus from our professor we were thrown upon our own resources and mutual help. Our daily conversation turned largely, apart from matters arising out of our immediate duties, around philosophical questions renewed occasionally in later years. On his side he was naturally influenced by his inheritance from Covenanting ancestors; I, on mine, by that from unorthodox and agnostic surroundings. As far as I am concerned, these most friendly conversations affected the whole of my more mature opinions. Chemically our life at the Andersonian was unsatisfactory. . . . As a consequence we both freed ourselves as soon as practicable from our engagements. He in 1874 entered into the serene and healthy atmosphere of the Glasgow University."

In the summer of 1873 Ramsay joined his uncle Andrew, who, with his sister and eldest daughter, were visiting the Rhine valley with a view to geological investigations. Two letters, one from Bonn (describing visits to Brussels, Antwerp and Cologne) and another from Lucerne, give an account in his usual frolicsome style of their chief adventures:

"LUCERNE, 1*st September*, 1873.

MY DEAR MAMA,

Here we are at Lucerne and have the prospect of staying till the day after to-morrow. We are going up the Rigi this forenoon: Aunt Eliza and Ella are going to glide up by rail and we are going to attack his monster sides ferociously, geologically and pedestrianly. The view is improving. It rained yesterday most persistently and with an energy worthy of a better cause. So we went to church in the morning and dined in the afternoon. Aunt Eliza took a scuttle in the afternoon into a R.C. Church and participated in the holy water and the various benefits accruing therefrom, thus showing that extremes meet. Ella,

Uncle Andrew and I sat and smoked the pipe of peace, at least most of us did. But to-day is rather better and so we are going to scale the hillock. . . . After staying three days in Bingen we went by steamboat to Mainz, where we stayed a night. Then my lamented relatives went on to Strassburg and committed some little follies in the way of sight-seeing there while I struck off for Tübingen viâ Heidelberg. I started at 10 a.m. and arrived at 7 p.m. The first person I knew was a railway guard, who recognised me instantly and we interchanged ideas to our mutual edification. Then as soon as I was stranded on the station I saw a mighty potentate, a Herr Oberamtmann Lindenmaier, greeted him and conversed for a time. Then I met some of the Kommerell's cousins (she) and conversed with them, and finally, having saluted the hotel-keeper and acquired a room, I saw the Kommerells standing down below. I devoted my best energies in giving a loud shrieking whistle. It was literally "Whuslin" on the fast day, for I had had nothing to eat since leaving at 7 a.m., but circumstances excused me. They glanced in the direction of the whistle, and gave me an amazed shout. Next moment we were (figuratively) in one another's arms and I would have fallen on Frau K.'s neck, had she had one to fall on. But she hasn't, I may say. To sum up all in one short word—"jolly." Having renewed old acquaintance and called on Fittig and spent the best part of two hours with him, on Friday I started for Basel, saw the Falls of Schaffhausen and met my bereaved relations at Basel next morning. They had come from Mainz and here we are. . . . When I have done Mont Blanc, Monte Rosa and the Matterhorn I shall write again. Adieu. Greetings all round. A kiss to pussy and two to Doran,[1] which you must do yourself or he will never forgive you.—Yours affectionately,

WILLIE."

About this time Ramsay became an "Abstractor" for the *Journal of the Chemical Society*, and continued

[1] The dog.

doing the work till he was appointed professor at Bristol in 1879.

In 1874 Ferguson succeeded Anderson in the Chair of Chemistry and he appointed Ramsay to the post of Tutorial Assistant. His duties consisted in holding classes to amplify the lectures. There were about two hundred, chiefly medical, students, attending the chemical lectures, and these were divided into four groups, and these had to be "coached" by individual question and answer and weekly written exercises. Each group came to the class twice a week and the consequence was that the teacher learned inorganic chemistry very thoroughly, but the work was monotonous and at the end of the six years in which he was thus engaged it was felt to be exhausting. But he gave some lectures on organic chemistry, which afforded some stimulus and led him to undertaking, though usually alone, some research in the laboratory, for at that time no one worked independently, except a few students whom he had persuaded. Among these were Arthur Smithells, now Professor in the University of Leeds, and J. J. Dobbie, afterwards Professor in Bangor and now Director of the Government Laboratory in London. As a result he published a notice of a new mineral, bismuthous tesseral pyrites, and a paper on the action of heat on sodium ethylthiosulphate. The cellars of the chemical laboratory contained the collection of pyridine bases left by Professor Anderson. Ramsay obtained possession of these and proceeded to their investigation. The fraction

containing picoline promised to be the most interesting. Beside their derivatives already known, he prepared compounds corresponding to the platinum-ammonium compounds with which he had been already occupied.

Experiments on the physiological action of some of these bases induced him to attend the lectures of Professor McKendrick, then recently appointed to the Chair of Physiology. The results of their joint experiments were published in the *Journal of Physiology*. The synthesis of pyridine from acetylene and prussic acid by passing them together through a heated tube was accomplished by Ramsay for the first time in 1877. About the same time, in association with J. J. Dobbie, he examined the products of oxidation of quinine and cinchonine. An interesting account of these researches and of the relations thus begun and continued through so many years between the two young men has been given by Sir James Dobbie in a series of recollections of which the following is an abstract. He says:

"I first met Ramsay in the summer of 1875, about a year after his appointment as Assistant to Professor Ferguson in the University of Glasgow.

I had completed my course for the ordinary M.A. degree and passed the usual examinations. I had also gone through the chemistry course with Dr. Anderson and had begun to work for honours in Natural Science and for the B.Sc. degree of Edinburgh University, there being then no science degree at Glasgow. Ramsay was delighted to find anyone whose views went a little beyond the routine that was followed by most of the students

and readily gave me assistance. Although no provision for teaching organic chemistry existed either in Glasgow or Edinburgh, I was required to get up the subject both for my honours exam. and for the B.Sc. degree. Ramsay saw my difficulty and very good naturedly undertook to read the subject with me, and together we worked right through Schorlemmer's *Chemistry of the Carbon Compounds*. As Ramsay himself had only recently returned from Tübingen, he was familiar with all the most recent developments of the theory of the subject and with the practical methods of investigation in which the German laboratories then excelled, and generously allowed me the full benefit of his knowledge and experience. He was desirous about this time of starting a class in organic chemistry, but the difficulties in the way were very great. He ultimately overcame them and obtained permission to deliver a short course of lectures. The experiment, however, was not very successful. The subject was not required for any ordinary degree, and the number of those who were interested in it for its own sake at that time was not large, and I do not think the course was ever repeated.

From the first, Ramsay engaged vigorously in research, for which his official duties left him a considerable amount of leisure. The atmosphere of the University at this time was not unfavourable to research. Kelvin was then at the height of his fame and Gilmorehill was the Mecca towards which all the distinguished foreign physicists who visited the country directed their steps. While at Tübingen, Ramsay had investigated the toluic acids and naturally continued on somewhat similar lines when he settled down at Glasgow. The cellars of the University Laboratory contained a large collection of fractions of 'Dippel-Oil' prepared by Professor Thomas Anderson. These were regarded by Ferguson, whose interest in chemistry was almost entirely that of the antiquary, more or less in the light of museum specimens, and he was horrified when Ramsay suggested that he should be allowed to 'investigate' them, but he eventually gave way

to Ramsay's importunity. The result was a very substantial addition to our knowledge of the pyridine bases and their derivatives. The original papers were published in the *Phil. Mag.* (Oct. 1876, Oct. 1877 and July 1878) and summarised in *J. Chem. Soc.* xxxv. 1879. While he was still engaged in this work, in which I occasionally assisted him, I completed my honours exam. and B.Sc. degree and won a scholarship which enabled me to remain at the University and gave me a certain status as Lecturer in Mineralogy. As my duties in this capacity, however, only occupied a part of my time, it was arranged between us in the autumn of 1876 that we should start an investigation of the quinine alkaloids. The method we adopted—breaking down by oxidation with permanganate—which has since been very extensively employed, led at once to important results. We obtained pyridine carboxylic acids from quinine, cinchonine, quinidine, and cinchonidine, and thus for the first time succeeded in establishing a connection between these alkaloids and the pyridine bases.

We had no idea when we commenced our work that any such a relation existed and, had it not been for the lucky chance that we were familiar through Ramsay's work on picoline with the peculiar smell of pyridine, the true nature of the acids we prepared would probably have remained long undetected. Our first paper was published in 1878—the work having been interrupted for a time by my absence during the summer of 1877 in Leipzig—and this was followed by a fuller paper in 1879. Attempts were afterwards made to ignore our work and to assign the discovery to Skraup, but an examination of the dates of the published papers puts it beyond all doubt that ours was the first published work on the subject.

Not long after we started the investigation, Ramsay's interests received an entirely new direction, and I was left to carry on the work alone, with only occasional help and advice from him. So far as I know he never again engaged in organic research.

In turning to the physical side of chemistry, I believe he was greatly influenced by Dr. E. J. Mills, who then held the 'Young' Chair of Technical Chemistry in Anderson's College (now the Royal Technical College), Glasgow, and of whom he saw a great deal about this time. Mills was then engaged in the study of mass action and elective attraction. Ramsay was greatly interested in this work and used often to talk to me about it. Another thing which certainly influenced him was Guldberg and Waage's work, which was only then becoming generally known in this country. When we were in Norway together in 1879 we tried to see Waage, but he was then on holiday. Ramsay, however, saw him the following year.[1] His first important research in physical chemistry was on the volumes of liquids at their boiling points,[2] but I cannot recall the exact circumstances under

[1] Extract from a letter from Bristol, dated 28th September, 1880:

"I called on Waage and he asked me to spend an afternoon with him at his country house—about half an hour's sail from the town. We had a long chat about things in general. He has given up his experiments on chemical statics. He speaks a little German, and with my knowledge of Norse, which as you know is surpassed by few and equalled by none of the natives of that country, we got along very well. He is great on the liquor question, and nothing would satisfy him but that we should hammer out a letter together to Gladstone, asking him to tax heavy beers with a proportionately higher alcoholic tax. I saw afterwards that the People's William thought it a good suggestion."

It would perhaps be proper to mention, for the information of the general reader, that Peter Waage was Professor of Chemistry in the University of Christiania. His fame rests on the thesis published by him jointly with his brother-in-law Guldberg, Professor of Mathematics, in which the fundamentally important principle, known as the "Law of Mass Action," is developed. Waage was born in 1833 and died in January 1900. A notice of his life and work will be found in the *Transactions of the Chemical Society* for 1900 (p. 591) from the pen of Ramsay himself.

[2] In the *Autobiography* Ramsay accounts for the origin of his interest in physico-chemical problems by reference to difficulties he encountered in determining the vapour densities of certain derivatives of dipyridine. Having used Victor Meyer's air-expulsion method, the idea occurred to him that the molecular volume of liquids at their boiling point could be determined by heating a glass bulb of known capacity, containing the substance, in its own vapour. "Once launched on the ocean of physical chemistry," he says, "numerous problems presented themselves."

which he took up this particular piece of work. It was whil blowing the bulbs used in this research, I believe, that he firs became aware of the value of the asset he possessed for physica work in his skill as a glass-blower. He had learned the art a Tübingen, although it was only in his later researches that hi marvellous manipulative power was fully developed.

In the 'seventies' physical chemistry had hardly attained th dignity of a distinct branch of the science, and there were n separate lectureships or professorships on the subject in thi country. Specialisation had been pushed a little further i Germany, and I remember attending a course of physical chemis try by Wiedemann in Leipzig in 1877, but the scope of his lecture was quite elementary.

When he turned to physical work Ramsay became aware o the defects of his mathematical equipment and would gladl have remedied them had that then been possible. He di arrange with one of the young University mathematicians fo coaching in the calculus, but the coach was not sufficiently kee for a man of Ramsay's ardent temperament and the arrangemen —fortunately, I cannot help thinking, because Ramsay coul not have gained sufficient proficiency in the higher mathemati to be of real use to him without the sacrifice of much time—wa soon abandoned and he continued to devote himself entirely t experimental work.

After he had been assistant for several years he became candidate for such chairs and lectureships as fell vacant, but me at first with little support. He was much discouraged by repeate failures, and I remember we discussed seriously a project fo starting together in business as chemical manufacturers. W both had connections in that line and were not unfavourab placed for such a venture. But fortunately before our plan had matured, the Chair of Chemistry in University Colleg Bristol, fell vacant by the removal of Dr. Letts to Belfast ar Ramsay was appointed his successor. He was greatly assiste

in this candidature by the close connection that existed between Glasgow University and Balliol College, of which Jowett was then Master. Jowett was a member of the Council of Bristol College. As was the practice in those days, Ramsay sought interviews with the individual members of Council before the election—in plain words canvassed them. He went up to Oxford armed with an introduction to Jowett from Professor Edward Caird. He was graciously received and invited to one of the Master's famous Sunday breakfast parties at which he met a distinguished company. At that time Ramsay had seen more of the world than most young men of his age. He was therefore well able to hold his own at the great man's table, and no doubt the impression he made was carefully noted by his host. As he was leaving, Jowett took him aside for a moment and made an appointment with him for the following day. When Ramsay called at the time fixed, Jowett, as if he had never seen him before, and without any other greeting, received him with a sharp 'Well?' Ramsay's feelings may be imagined, but he grasped the situation, stated his business as briefly as possible, and took his leave. Jowett proved a good friend. He not only supported Ramsay's candidature, but afterwards invited him repeatedly to Balliol, and evidently formed a just estimate of his character and intellectual powers.

In the Glasgow laboratory Ramsay exhibited all the characteristics which afterwards became so marked and so generally known. He was a rapid worker; came quickly to conclusions; was bold almost to audacity in the things he attempted; and worked with surprising energy and industry. The only relaxation he allowed himself during the day was an occasional cigarette. As smoking was forbidden in the main laboratory where the students were at work, he retired to the smaller or private laboratory where the professor's assistants and one or two senior students, who occupied a privileged position, had their work benches. There with his back against the radiator he would

roll his cigarette, a life-long practice, and retail or listen to latest story or the last piece of University gossip. He had a k sense of humour and delighted especially in the oddities 'Chemical' or 'Comical' John, the bottle washer of the est lishment. John was a great character, a strange mixture shrewdness and simplicity. It was noticed that he absen himself for a few minutes at exactly the same time every morn and on being followed one day it was found that he went to his watch by the great clock in the quadrangle. As he was responsible for the time-keeping, he was questioned as to why was so particular to have the exact time. He confessed then t he stopped his watch every night and set it going again in morning. 'You see,' he added, 'it will last just twice as l that way.' Ramsay had a keen appreciation of such humour

He frequently spent his week ends with an aunt at Kilcreg on the Clyde, and if I remember aright sometimes travelled and down daily. He had been employed to assist in tr lating Wurtz's *Dictionary of Chemistry* for a firm of Glas publishers, who proposed to bring out an English edition project which was afterwards abandoned, although a very l part of the translation was actually completed.

He always carried about with him, on his journeys, wr material and some sheets of the French text. He wrote ease in the train or on board the steamer, and as he was pai much per sheet he would sometimes remark to me as he ent the laboratory that he had earned so much on the way u town. He translated with great rapidity, and possessed the he did all through life, the power of expressing himself easily correctly. His letters written at this time, of which I preserved a few, are excellent—gossipy, vivacious, and unconventional in style.[1] His handwriting differed little that of later years, except that it was not quite so regular became subsequently.

[1] One of these letters will be found on a later page.

But it was not all work with him. He enjoyed life thoroughly, was fond of society, and went out a great deal to dinners and dances. He was an excellent waltzer, and that and his other social gifts made him much sought after in Glasgow society. Walking and climbing were favourite recreations in which I was frequently his companion. We sometimes spent the week-end together either at his aunt's at Kilcreggan or at Fairlie, my own people's summer quarters. Boating was another favourite amusement. Ramsay had some skill in the management of a lugsail, but with later experience of that treacherous rig I look back with a shudder to a morning I spent with him off Kilcreggan on one of the most dangerous reaches of the Clyde, for he was as venturesome on the water as on the land.

In the spring of 1878 we made a short walking tour together through the Western Highlands. Starting from Ardentinny (sung by Wordsworth) on the Clyde we walked to Inveraray, thence to Dalmally at the head of Loch Awe and so on to Oban. We had many adventures by the way, which provided us for long afterwards with matter for jest and laughter. From Dalmally we climbed Cruachan (on a Sunday !), and I remember, when we were standing on the top admiring the magnificent landscape, Ramsay drew my attention to an eagle soaring high above us, the first, I think, either of us had ever seen. We descended from Cruachan into the Pass of Brander, the scene of one of Bruce's most noted exploits and sacred ground to us on that account, for we had been bred up in all the traditions of Scottish patriotism. Whether under the stimulus of that feeling, I do not know, but we thought to beguile the time by composing a rhyming chronicle of our journey. The only couplet I can now recall was one composed by Ramsay :

> 'And in the Pass of Brander
> The scenery grew grander,'

and I think that is probably a fair specimen of the level to which our poetic flight rose. An amusing incident took place at Oban.

We shared the same bedroom, as was our custom, and before retiring for the night both remarked that the arrangement of the room and furniture was exactly the same as in the inn at Dalmally on the previous evening. Early in the morning I was awakened by a loud voice declaiming: 'Our travellers were now put into a room in all respects like unto the former, and if anyone thinks it was otherwise he is entirely mistaken.' Ramsay was delivering a lecture in his sleep. He was very wroth when I woke him and told him what he had said. For long afterwards, whenever he was more emphatic in the assertion of an opinion than I thought the occasion warranted, I used to remind him of his dream at Oban and he always took the hint with perfect good humour. From Oban we went by steamer to Fort William and the following morning, the first of May, climbed Ben Nevis. We found the upper part of the mountain covered with snow and had some difficulty, and lost a good deal of time, in getting down into Glen Nevis up which we proposed to walk to the hamlet of Kinlochmore near the head of Loch Leven. We expected to find shelter there for the night, but in this we were disappointed, and had to choose between crossing by a rough mountain track to King's House near the head of Glencoe and walking to Leven Hotel opposite Ballachulish, a distance of 26 miles reckoning from our starting-point in Glen Nevis. As the daylight was nearly gone when we reached Kinlochmore and there was no moon, the former alternative was out of the question. We therefore made our way as quickly as possible down to the loch, not without difficulty in the failing light, and for more than two hours had to march in pitch darkness before we came opposite Ballachulish. The question then was how to find the hotel? Luckily we came upon a house in which a light was burning and the occupier who had been kept up late by some domestic occasion good naturedly guided us to the inn. After much banging and rattling we succeeded in rousing the landlord, who not only found us a room, but when he knew our plight, with true Highland

hospitality, provided us with a good supper. It was then nearly one o'clock in the morning. We had been out from 6 o'clock of the previous morning and had been afoot climbing and walking all the time, with no other food than a few sandwiches. Next day we intended walking up Glencoe, but our feet were badly bruised with the previous day's climbing and we were glad to wait for the steamer and sail back to Oban.

It was on this trip that I first became aware of Ramsay's aptitude for languages. In all our conversations he had never, so far as I can remember, shown the slightest interest in philological studies, although he spoke German fluently and had gone through some at least of the University classes in Greek and Latin. But as soon as we got amongst people actually speaking another language his interest was aroused. We both knew a few Gaelic words, as most inhabitants of the West of Scotland do. I was content to let it rest at that, but Ramsay was bent on learning Gaelic and extracted words from every Gaelic-speaking person we came across. What struck me as peculiar was that he took little or no interest in the traditions or manners of the Highlanders, only in their language.

In our Highland tour we had proved that we were pretty equally matched as regards our powers of physical endurance and that we possessed the compatibility of temperament that is essential for the success of such expeditions. We resolved accordingly on a walking tour on a more extended scale in Norway in the long vacation of 1879. We sailed from Leith to Christiansand and were fortunate enough to have as one of our fellow-passengers Dr. Amund Helland, now one of Norway's foremost geologists and at that time, I believe, a privatdocent attached to Christiania University. When he found that Ramsay was a nephew of Sir Andrew Ramsay and that we were both interested in geology and mineralogy he became very friendly with us and sketched out a plan of tour which we found of the greatest assistance. As he was in no hurry to return to Christiania, he

volunteered to accompany us to Hitter in Flekkefjord, where large pegmatite veins occurring in the 'Norite' of the island had recently been opened up and found to contain many rare minerals. Accordingly after a night's rest at Christiansand we caught a coastwise steamer going north, which landed us on Hitter. There was no inn on the island, but we got comfortable quarters in a fisherman's house which was built on a ledge of rock overhanging the fjord. Here we fed sumptuously on trout, salmon, eggs, milk, flad brod, and coffee, our first experience of genuine Norwegian fare. The granite veins of the island were a sight never to be forgotten. The crystals of felspar, mica, and quartz were of enormous size, compared with anything we had previously seen, and mingled with them and projecting from the roof and sides of the cutting were large bosses of euxenite, orthite, and other minerals of the rare earths. On receiving Helland's assurance that there was no objection to our helping ourselves, we secured a goodly supply of fine specimens—most of which are now in one or other of our museums—and dispatched them to Christiania to await our arrival there. Long afterwards, when Ramsay was engaged on his search for sources of the rare gases of the atmosphere, he bethought him of our Hitter finds and made a systematic examination of them. The only one, however, which gave him any positive results, was 'Malacon,' a hydrated variety of zircon, which he found to contain helium. Helland returned direct from Hitter to Christiansand and we crossed to the mainland and made our way by carriole, train, and steamer to Bergen and thence sailed up the Hardanger Fjord to Odde. We made many acquaintances in Bergen and on board the steamer, some of whom we met again and again in the course of our tour. Amongst them I particularly remember two daughters of the Federal General Lee. As we sailed up the Fjord we were constantly reminded, especially in the lower reaches, of our own Scottish lochs. The last part of the sail, where the Fjord narrows and the mountains seem in places to rise sheer from the water,

is very grand, especially when seen as we saw it in the deep shadows of an autumn evening with the moon lighting up the white edge of Folgefond snowfield, where it shows through the clefts of the rocky summits. Young Scotchmen are not usually sentimental and are not given to expressing their feelings on such occasions, and we were silent. But the spell of the fjords was upon us from that time and we both re-visited them, although not together, again and again. Odde, the landing-place at the head of the Fjord, was then quite unspoiled and consisted of little more than a picturesque hotel near the landing-stage, and a few scattered houses. Now, I hear, all is changed by the huge nitrogen works which have been erected in recent years. We stayed here several days, visiting the Buarbrae (Glacier) and the Skjaeggedalsfos—a fall of from 500 to 600 ft. We were both greatly interested in the geological features of the country and spent much time in examining the action of the glacier, the moraines, the cirques and, later on, the raised beaches, which are nearly everywhere along the coast such a prominent feature of Norwegian scenery. Ramsay was well informed as to his uncle's views, which afforded us material for many discussions and much speculation in the light of our own experience. Our visit to the Skjaeggedalsfos was a memorable occasion. The way was long and rough and the journey had to be performed entirely on foot, but we felt fully rewarded by the magnificence of the scene; it was the first of the great falls we visited. On the way back we were caught in a perfect deluge of rain and got soaked to the skin. We had no change of clothes with us, as we carried nothing but our knapsacks. When we reached the inn, our host, evidently quite accustomed to such experiences, turned out various ancient suits that must have been in his family for generations and in these we adorned ourselves for supper. Presently two Austrians, who had also made the excursion to the fall, returned in the same condition as ourselves. By this time the clothes of the inn had all been appropriated,

but the Austrians were not to be beat. To the delight of the other guests they appeared at supper in kilts improvised for the occasion out of Norwegian homespun bed coverlets, which were decorated with the beautiful coloured border common in this part of Norway. They were both large-sized men of the typical South German build, and their appearance in this guise was the signal for general merriment, especially when one of them proceeded to execute a dance. We were all in high spirits after our day in the open air. The Austrians were capital fellows, full of jokes and stories, and we spent a very merry evening together. We found out later, when the time came for the inevitable exchange of cards, that one of them was a judge in one of the higher courts of Vienna and the other an advocate who practised in the same court. We saw a good deal of them afterwards and found them excellent travelling companions. From Odde we made our way by steamer, rowing boat, and on foot to Vossevangen, where we rested for a few days. One evening spent here dwells in my memory. The hotel, at that time one of the few hotels in Norway outside the large towns, was much frequented by Norwegians from Bergen. It boasted a piano, and after supper Ramsay commenced to play and then to whistle,—an accomplishment in which he excelled. Soon this unusual form of entertainment attracted listeners, and after a time all the guests were gathered round him applauding vociferously. Then we sang national songs, and all went merrily until we came to the Marseillaise, when three Germans, who were of the party, clapped on their caps and strutted out of the room to the intense amusement of the rest of the company. At that time the Germans had neither destroyers nor submarines and the Norwegians stood in no fear of them.

Most of our travelling was done on foot. We carried nothing with us but our knapsacks and it was necessary to wash up from time to time, which we generally did for ourselves, retiring to some secluded spot by the side of a stream for the purpose, and hanging out our washing afterwards over our knapsacks to

dry as we marched. We halted for a day or two at intervals to rest and refit. During these rest periods we usually devoted our time to exploring the immediate neighbourhood of our stopping place, making the more intimate acquaintance of the people, and trying to pick up what we could of the language. We had with us a Norse Dictionary, a never-ending source of amusement on account of the quaint equivalents with which it abounded. But we trusted to what we could learn viva voce, and must have made some progress with the language, for I find amongst my letters several in Norwegian from travel acquaintances which contain the assurance that my knowledge of their language was a sufficient excuse for using it in writing to me. Ramsay's great aptitude for languages enabled him to make very rapid progress, and he afterwards continued the study both at home and on subsequent visits to Norway and became very proficient in it. I noticed in Norway again what I have referred to in connection with our Highland trip, that his interest in the language was much greater than in the history and traditions of the people, to which so far as I remember he paid very little attention. He took great pleasure, however, in the Norse folk-songs, many of which we learned from chance companions on our walks. We found great interest in compiling lists of Scandinavian words which, although not known in England, are in common use in Scotland. These words were either introduced into Scotland by Scandinavian settlers or are survivals of the common Teutonic vocabulary which persisted in Norway and in the northern parts of the British Isles after they ceased to be used elsewhere. I remember the delight with which we first heard 'barn' (Scot. bairn) 'child,' and 'gjöre' (Scot. gar) 'make do,' and many others with which we had been familiar from our earliest days but had never before heard out of our own country.

Another amusement of Ramsay's during our longer halts was sketching in water colours, an art in which he possessed no inconsiderable share of the talent which belongs to his cousins,

Sir Andrew Ramsay's family. His sketch book was in existence quite recently and may be so still. He took particular pleasure showing me from time to time a drawing he made of me while I was bathing and supposed he was engaged in sketching the surrounding scenery.

After leaving Vossevangen we went by way of the Nerodal, famous for its beautiful white labradorite felspar rocks, and Gudvangen to Loerdal on the Sogne fjord, and thence crossed from Skjolden into the Jotunheim, to see something of the great alpine lakes and to climb Galdhöpig, the highest peak in Norway. Rødsheim, from which we made the ascent, is one of the most delightful of Norwegian stations, where, at that time at all events, Norwegian life could be seen in all its native simplicity, little if at all spoiled by any contact with the outer world. Rødsheim,—in Norway as in Scotland the proprietor is often known by the name of his farm or estate,—found us a guide in Knut Volo, the village shoemaker. We were in no way equipped for an alpine climb, but Volo, after inspecting our boots professionally, and strengthening them with some nails, undertook to go up the mountain with us. The greater part of the ascent consisted of a long walk, which presented no kind of difficulty until we came to the great glacier which had several ugly crevasses to be crossed. The upper part of the mountain was covered with a sheet of frozen snow, over which we had to cut every step we took. We astonished our guide by bathing in a small tarn high up on the mountain. Large masses of ice were floating about in the water, which was of course bitterly cold. Volo evidently thought we were stark mad, the feeling which I am afraid our doings and the doings of many other Englishmen abroad often arouse in the foreigner. It was a foolish proceeding, and had we not been in first rate physical condition at the time might have cost us dear.

On emerging from the Jotunheim, we crossed into Gudbrandsdal, and from Domaas made the ascent of Snehaetta, the second highest mountain in the Dovrefjeld. This was one of the least

interesting of our excursions, nothing but a long 14 hours' tramp over moor and barren hill side, and I only mention it as another illustration of Ramsay's powers of endurance in the seventies. We next descended the Romsdal, and after a day or two spent at Molde went on to Throndhjem, from which we returned by rail to Christiania.

At Christiania we again met Helland, who showed us over the city and initiated us into the mysteries of Scandinavian politics. We learned then for the first time of the cleavage between Swedes and Norwegians. We had met few Swedes in the course of our trip and had often been struck by this. Even then the movement which subsequently led to the separation of the two countries was in progress. The Norwegian flag, in which the Swedish colours were quartered with those of Norway, was always referred to as the 'dirty' flag and we were assured that the Norwegian people would never rest satisfied till it was cleansed—an aspiration which was satisfied sure enough but not till many years afterwards. Helland himself was closely identified with the young Norway party and introduced us to several of the notabilities in politics and literature at the University club.

We left Norway after a six weeks' tour with the pleasantest memories of the country and its people. We both returned repeatedly but never again in company. Our passage back was very rough. Ramsay was a good sailor and I a bad one, but I think that was the only advantage he had over me as a traveller.

After Ramsay's removal to Bristol he continued to visit Glasgow periodically so long as his father and mother were alive, but of course I saw much less of him than formerly, and although we continued to correspond, I have little to tell regarding the period after 1880."

It has not been thought advisable to interrupt the interesting story told by Sir James Dobbie, but one or two incidents not referred to in these notes are recalled

by letters which have been preserved, some addressed to his parents and some by the same friend. In 1876 the British Association met in Glasgow, and Ramsay's name appears for the first time in the list as an annual subscriber, but no communication from him is recorded. The following year he attended a meeting of the Association Française pour l'Avancement des Sciences at Havre. The following letter to his friend Dobbie gives an account of his doings :

"LE HAVRE,
Monday, the Something or other August, 1877.

MY DEAR DOBBIE,

Some fool of a Frenchman has stolen all the paper belonging to the French Association, and has left only this half sheet with Le Havre at the top. From the preceding sentence you will have already guessed that the French Ass. is capering around Havre at present, that I form one of the distinguished foreign members, and that all is going as merrily as a marriage bell. Voici 5 jours that I find myself here. I went to Paris with three spirits more wicked than myself, lawyers—a fearful compound 3 lawyers[1] and a chemist,—just like NCl_3 for all the world, liable to explode at any moment. Their names were Mr. Smith from London and two others with less aristocratic designations. I shall sum up all our exploits shortly thus—Sleep, grub and amusement,—such was the programme. I called on Wurtz, Schützenberger, Silva and others and heard that there would be no chance of my doing anything in Paris, and that all the chemists would be absent at Havre. So as I was a fortnight too soon I accompanied my friends to Havre,

[1] These were H. B. Fyfe, Guthrie Smith and Charles MacLean. See Mr. Fyfe's notes, Chapter I. p. 22.

secured rooms, took a walking tour in Normandy and Brittany for a fortnight, and behold me at length here since last Wednesday, taking part in the Ass.

It is the best thing I could have done, for I have made the acquaintance with a whole lot of chemists, Dutch and French, and have found an old Dutchman named Gunning ravished to find someone who shares his ideas about *matter*, chemical combination, etc. We excurted together yesterday the whole day and talked French and German alternately all the time. When we wanted to be particularly distinct precise French was all the go. For energy and strong denunciation German came of use. You can't say 'Potz-teufel!' in French or 'Donnerwetter potztausend sacramento!'

An old cove, also a Dutchman, De Vrij, with bowly legs and a visage like this [sketch profile] is also a very nice old boy. The nose is the chief feature of resemblance in the annexed representation. Wurtz and Schützenberger are both Alsatians and of course are much more gemüthlich than the echter Franzose, but on the whole the fellows I have got to know are very pleasant. Some of the younger lot and I kneipe every evening. Then we bathe every day too in fine stormy water.

Eh bien, what is there to say of more? I am going straight back to Glasgow on Wednesday by the special steamer to Glasgow. My money is about done, so I must bolt. I have done with holidays this year and am as a giant awakened. Do come back before the session commences, and let us get some work done. By the way I forgot to tell you that I had the cheek to read a communication on picoline, in French, which was received with loud applause. There were some remarks made afterwards very favorable, tho' I say it as shouldn't say it. Adoo. Write to Glasgow and tell me Wie's geht.

Yours very sincerely,

W. Ramsay."

The next year he attended the British Association meeting in Dublin and communicated two papers, "A Summary of Investigations on the Pyridine Series" and on "Some of the Derivatives of Furfurol," beside showing Victor Meyer's apparatus for taking vapour densities of substances with high boiling points.

In a letter to his friend Dobbie he remarks: "By the way the British Ass. is going to Bray this year."

This letter was written from Wales, where apparently he had been staying with his uncle's family, "dolce-farnienteing in a delightful manner. Lawn-tennis, bathing, mild (and harmless) spooning, hill-climbing, etc. (Etc. being all the other vices practised at a place bordering on hills and sea), have been the sole aim and object of existence since I came to Wales."

In 1879 the promotion for which he had so long been hoping came at last. He was appointed Professor in University College, Bristol, and took up his new work early in the new year. The following extract from a letter speaks for itself:

"University College, Bristol.
12*th March*, 1880.

My dear Dobbie,

This letter must be written *en* Jingle. Arrived safe—Monday night—fair lodgings—change with Marsden when he goes next Monday—like the place—Lab. in confusion but good—Fifteen students in Lab. 40 at lectures—Nicol lecturing till end of term—Marsden nice fellow—going to Germany at once."

It is interesting to note that the last meeting he ever attended was also at Havre in August 1914, which broke up disastrously at the outbreak of war. A letter describing what happened on that occasion will be found on a later page.

CHAPTER III

THE BRISTOL PERIOD

THE years following 1870 saw the beginning of that great national movement which has resulted in planting new universities and colleges connected with universities over the United Kingdom. Up to that time institutions which gave higher education and instruction corresponding to that which was provided by the ancient universities of England, Scotland, and Ireland were only to be found in Manchester and London. In the former city the college which bears his name was founded by John Owens in 1851. In London there were three colleges, namely University College (the original University of London) founded in 1826, King's College founded in 1829, and Bedford College for Women founded in 1849. For nearly twenty years these institutions struggled, with somewhat indifferent success, against mid-Victorian prejudice and nervousness, as indicated by the sensation produced by the publication of *Essays and Reviews* and the storm aroused by Darwin's *Origin of Species* and *The Descent of Man*. But in 1871 the first step toward a new state of things was repre-

sented by the foundation of the Armstrong College at Newcastle-on-Tyne. This was quickly followed by the establishment of the University College of Wales at Aberystwyth in 1872 and the Yorkshire College at Leeds in 1874. On the 11th June, 1874, a public meeting was held in the Victoria Rooms, Clifton, Bristol, with the object of promoting the establishment of a college of science and literature for the West of England and South Wales. The movement thus initiated was supported by the influence and financial aid of the two great Oxford colleges, Balliol and New College. Among its most ardent promoters were the Master of Balliol (the Rev. Dr. Jowett), the Headmaster of Clifton College (the Rev. Dr. Percival, afterwards Bishop of Hereford), Mr. Lewis Fry, M.P., and Mr. Albert Fry, who afterwards became the very active Chairman of Council, together with several other Bristol citizens, among whom may be mentioned William Killigrew Wait, who became Vice-Chairman, and William Proctor Baker, who acted as Treasurer. A second meeting was held the following year, on the occasion of the meeting of the British Association in Bristol, and in 1876 the College was opened. The premises first occupied were situated in Park Row, near the top of Park Street, and consisted of a very old and dilapidated house where the classes were carried on and a chemical laboratory fitted up while the permanent buildings were in process of erection. The first Professor of Chemistry was Dr. E. A. Letts, who left at the end of 1879 on being appointed to the

Chair of Chemistry at Belfast, then vacated by Dr. Thomas Andrews, F.R.S. Ramsay had also been a candidate for this post, but luckily for Bristol he was not selected, and in February 1880 he was chosen to succeed Letts. Conditions in reference to teaching appointments have been ameliorated since that day, but it is interesting to place on record the stipend and duties of a professor of chemistry in a university college forty years ago:

UNIVERSITY COLLEGE, BRISTOL.

CHAIR OF CHEMISTRY.

The Stipend will be £300 per annum, with two-thirds of Lecture fees and one-third of Laboratory fees. The Council guarantee a minimum emolument of £400 per annum.

The Laboratory expenses will be borne entirely by the College. The Laboratory student's fee will be £18 18s. 0d. per session (with reductions for shorter periods).

The session will commence at the end of the first week in October, and continue until the end of June. (In after years the Professor may be required to give instruction in Practical Chemistry during July to medical students.)

The Professor will be required to give three lectures per week for the first two terms, say 60 lectures, together with class instruction in connection therewith (student's fee for this course, £3 3s. 0d.), and a short course of lectures in the third term. He will also be required to superintend the Laboratory during the whole session, and to give evening lectures once a week during the first two terms, together with class instruction in connection therewith (Evening-Class fee, 10s.).

A competent assistant will be provided.

The scheme of the College contemplates the possibility of

occasional lectures being delivered in neighbouring towns by the Professor or his Assistant.

In connection with the Cloth-working Industry, special instruction in dyeing, etc., may be required under an arrangement not yet concluded with the Worshipful the Cloth-workers' Company of London.

It will be observed that no mention is made of research, and the number of lectures is somewhat indefinite, though appreciably less than the number introduced into the programme of other colleges established about this time.

The state of things at Bristol is illustrated by the following extracts from a letter of Ramsay's, dated 4th March, 1881 :

"I have been very hard worked and am still. The beastly Trowbridge lectures take it out of one so much, both in the loss of a whole day, as well as in preparation. I haven't done a stroke of original work this term, for all my time has been absorbed in learning how to dye. . . . Otherwise I have eight lectures a week, which means a lot of time. I long for summer with three lectures a week and nothing else but laboratory. . . . Otherwise things here are very quiet. I have no time to go out to dinner, etc., and have consistently refused. All I keep up is the singing club on alternate Fridays, but that even I have missed for the last two meetings. I'm going to-night."

The first Principal of the College was Alfred Marshall, afterwards Professor of Political Economy at Cambridge. He resigned in 1881, and in September of that year Ramsay was appointed Principal in his place.

The following letter from Professor Marshall to

Lady Ramsay on 24th July, 1916, explains the circumstances :

"You will be overwhelmed with letters from far and near, which speak with better knowledge than mine of the terrible loss that has befallen the world's science: my only claim to speak of him is that he rendered me the greatest of all services. In the autumn of 1880 I was rapidly dwindling. I knew that each month of my stay at Bristol materially lessened my chance of living to do any considerable part of the work on which I had set my heart. The Council of University College, Bristol, declared that the condition of their finances prohibited their advertising for a new Principal. The new Professor of Chemistry began his work in late September, by the middle of November I knew I was free. For a true strong MAN had come to the College, and young as he was I knew that the destinies of the College were safe in his hands. They turned out to be much more than safe."

The following extract from a letter sent by the Council of the College to Professor Ramsay, 28th September, 1881, shows the conditions of the appointment :

"That Professor Ramsay be appointed Principal of the College, and that he receive as Principal, in addition to his present remuneration as Professor, one-eighth of all the fees, other than entrance fees, with a guarantee that his share of such fees shall not be less than Two Hundred and Fifty Pounds per annum (£250), and that the engagement be terminable by either party on three months' written notice."

To a young man under thirty years of age, and just married, the temptation of a substantial increase of income was no doubt irresistible. But it can easily be understood that the additional burden of duties

Professor Ramsay in 1881

might reasonably be expected to curtail seriously the time available for study and the continuance of experimental research. This, however, does not seem to have interrupted the output of results from Ramsay's laboratory, for in the years 1881 and 1882 five papers were communicated to the Chemical Society, one being the joint production of the Professor and the Demonstrator David Orme Masson, who later became Professor of Chemistry in the University of Melbourne.

Ramsay was fortunate in having a succession of able assistants in the teaching work. Masson left the College in 1881 and was succeeded by Dr. Adrian Blaikie (who died a few years after leaving Bristol in 1882), and for a very short time Mr. W. L. Goodwin occupied the post. He was succeeded by Dr. Sydney Young in 1882, who remained in association with Ramsay till the departure of the latter five years later for University College, London. Young was then appointed to the vacant chair. When Dr. Young went to Bristol in 1882 he found Ramsay engaged in two investigations: the first on the specific volumes of liquids at their boiling points, and the second the determination of the vapour pressures and critical constants of benzene and ether.

The supposed phenomenon of "hot ice" had also just previously occupied a good deal of attention, and in the investigation of all these subjects Ramsay invited Young to join him. The result was a series of papers on the thermal properties of solids and liquids and on the relation of evaporation to dissociation, which extended

over and beyond the whole of the five years in which the authors were associated together. This period is so full of scientific interest that Professor Young, at the request of the writer, has been good enough to prepare a résumé of the whole of the results of their joint work, and has added a complete list of the papers in which it originally appeared. The list of papers will be found at the end of the chapter.

Professor Young's notes are as follows:

"I was one of the Secretaries of the Owens College Students Chemical Society at the time of the discovery by Carnelley that ice, when heated under very low pressures, cannot be melted. This discovery aroused great interest, and Sir Henry Roscoe asked me to show the experiment to the Chemical Society. On considering the matter I came to the conclusion that the volatilising point of ice, like the boiling point of water, probably depends on the pressure. If Carnelley's opinion that the temperature of ice rises above 0° C. (strictly speaking 0·007°) was incorrect, it would probably be found that the vapour pressure curve for ice is identical with the volatilising point curve, just as the vapour pressure curve for water is identical with the boiling point curve. If, on the other hand, the ice really becomes hot, there must be a new curve, as yet undetermined. I gave this explanation when showing the experiment at the meeting of the Chemical Society, and it was at once accepted by Bohuslav Brauner, then a Fellow of Owens College (now Professor at Prag), who advised me to publish the paper at once. Sir Henry Roscoe, however, was less confident and dissuaded me from sending in the paper. Afterwards there was much discussion in *Nature* and other journals, and after Pettersson had given a somewhat similar but partly incorrect explanation, I wrote a letter to *Nature* stating the facts and giving my explanation. [*Nature*, **24**, 239 (1881).]

I then spent a year at the Strassburg University and, while there, took lessons in glass-blowing from a professional glass-blower. In Bristol, after making a Wollaston's cryophorus for my evening lectures, it occurred to me that by altering the size of one bulb and fusing in a glass rod ending below in a knob about the centre of the smaller bulb, one might get a block of ice suspended in this bulb and Carnelley's experiment might be much more easily carried out than by his rather cumbrous method.

The result was quite satisfactory and I showed the experiment to the Owens College Chemical Society, and described the apparatus in the *Chemical News*, 47, 104 (1883), mentioning at the same time that Prof. Ramsay and I proposed to investigate the question of the temperature of the ice by inserting a thermometer in each bulb. The thermometer in each case was passed through a tube of suitable size, a wired indiarubber tube serving to keep the thermometer in position and to make the cryophorus airtight. With this apparatus we were able to prove that the ice does not become hot even when the temperature to which it is subjected is very high, and also that the temperature of the ice falls when the pressure is lowered by cooling the larger bulb by means of a freezing mixture. A fair estimate of the pressure was afforded by the temperature in the interior of the cooled bulb, knowing the vapour pressures of ice. A narrow side hole, provided with an indiarubber tube and a screw-clip, was added, and through this air could be admitted so as to raise the pressure very slightly.

The results obtained were very encouraging, and the next step was to make direct measurements of pressure by connecting the cryophorus with an air-pump and manometer; and it afterwards occurred to us that the method might be used for liquids by covering the bulb of the thermometer with cotton-wool and admitting fresh liquid, as required, to moisten the cotton-wool by means of a vertical tube provided above with a stopcock (or indiarubber tube and clip) and reservoir, and drawn out sideways.

at the bottom into a jet impinging on the thermometer jus above the wool. We found that this worked very well, and tha in the case of water, benzene, etc., the liquid on the cotton-woo could be frozen, so that both boiling points and volatilising point could be determined with the same apparatus. [*Phil. Trans* **175**, 37 (1884).]

In the case of water we used an apparatus with two vertical tubes provided with thermometers, etc., so that we could have ice on one thermometer and supercooled water on the other, the pressure being necessarily the same in both cases. We were thus enabled to verify Prof. James Thomson's theory of the vapour pressures of solid and liquid in the case of water, benzene, acetic acid and camphor. But to make the proof complete, it was advisable to ascertain definitely whether the statical (barometer tube) and dynamical (boiling or volatilising point) methods gave the same results. Accordingly determinations of vapour pressure were made with a barometer tube of a form specially adapted for the complete removal of air either dissolved in the liquid or adhering to the walls of the barometer tube. [*Phil. Trans.* **175**, 461 (1884), also *Phil. Mag.* **23**, 61 (1887).]

The barometer tube was heated by the vapour of a pure liquid boiling under known reduced pressures. From these pressures the temperatures were ascertained from tables of vapour pressure previously compiled.

In order to have at our disposal a wide range of temperature, we required to know the vapour pressures of a series of stable liquids, easily obtainable in a pure state. The substances we adopted were carbon bisulphide, ethyl alcohol, chlorobenzene, bromobenzene, aniline, methyl salicylate, bromonaphthalene and mercury. [*Trans. Chem. Soc.* **47**, 640 (1885).] Regnault had already determined the vapour pressures of carbon bisulphide, ethyl alcohol and mercury, and we accepted his values, though it was found subsequently that considerable corrections were required in the case of mercury. We had to

determine the vapour pressures of the other substances ourselves, and for this purpose we employed our new method already described [see also *Trans. Chem. Soc.* 47, 42 (1885)], and we also made a few determinations with an air thermometer to obtain fixed air-temperature points on our scale.

The pressures were plotted in each case against the temperature and were then read off for each degree over rather a wider range than that actually required. I undertook to smooth these pressures by the method of differences, and in doing this I noticed:

(1) That in the case of chlorobenzene and bromobenzene the value of $\frac{dp}{dt} \cdot T$ at any given pressure was the same for both substances, and that with the other substances, excepting perhaps ethyl alcohol, the values of $\frac{dp}{dt} \cdot T$ at any given pressure showed only moderate differences. I found also that the relative values were about the same whatever the pressure chosen.

(2) The ratio of the absolute temperature of bromobenzene to that of chlorobenzene was the same at all pressures, taking always the same pressure for both substances, and I found afterwards that this is the case also for other pairs of chemically closely related substances; or $R' = R$, where R' is the ratio of the absolute temperatures at a pressure p' and R is the ratio at a pressure p.

I had at this time secured a copy of Regnault's complete researches, and I made a thorough study of his determinations of vapour pressure and thus obtained confirmation of the above generalisations. In a joint paper, read before the British Association in 1885 at Aberdeen, Ramsay gave an account of the closely allied generalisation, $\frac{L}{v_1 - v_2} = \text{constant}$ (approximate) at the same pressure, and I described the above generalisations (1) and (2).

For less closely related substances the simple relation $R' = R$ does not usually hold, but I found the equation $R' = R + c\,(t' - t)$

to hold accurately, where c is a very small constant, and t' and t are the temperatures of one of the two substances at the two pressures p' and p.

The first generalisation is closely connected with the formula of Clausius and Clapeyron,

$$\frac{L}{v_1 - v_2} = \frac{dp}{dt} \cdot \frac{T}{J}.$$

Ramsay had previously studied the first term of the formula, $\frac{L}{v_1 - v_2}$, chiefly at atmospheric pressure, and had communicated his results to the Chemical Section of the Philosophical Society of Glasgow in 1877, but the generalisation in the form $\frac{M.L}{T}$ = constant at atmospheric pressure for different substances was first actually published by Trouton [*Phil. Mag.* **18**, 54 (1884)], and is known as Trouton's law.

Finally these and another allied generalisation were published by us in a series of five papers termed 'Some Thermodynamical Relations,' Pts. I. to V., *Phil. Mag.* **20**, 515 (1885); **21**, 33 and 135, **22**; 32 and 37 (1886).

I found that Regnault's vapour pressures of mercury below the boiling point, when compared with those of one of the other substances, gave results which did not agree with the formula $R' = R + c(t' - t)$, and on reading all his papers bearing on this subject I found that Regnault at an early date had made rough determinations of the vapour pressures of mercury below the boiling point and that, at a considerably later date, when he made his complete investigation over a wide range of temperature, he evidently forgot that his early experiments made no claim to great accuracy, and he adopted them without further verification. We therefore found it necessary to redetermine these vapour pressures, and we carried out experiments with special apparatus between 220° and the boiling point of sulphur. We employed the equation $R' = R + c(t' - t)$, taking water as the standard

substance, for interpolation and for extrapolation below 220°, and we found that below this temperature Regnault's pressures were much too high and that the formula $R' = R + c(t' - t)$ was applicable to our results between 220° and 440°, though not to Regnault's. [*Trans. Chem. Soc.* 49, 37 (1886).]

The two generalisations were found not to be applicable, as a rule, to dissociating substances, nor, for a very wide range of pressure, to compounds containing a hydroxyl group, such as water, the alcohols and the fatty acids. For moderate ranges of pressure, however, the deviations are hardly noticeable in the case of the hydroxyl compounds, so that no serious harm has been done by choosing water as the standard substance.

Landolt's vapour pressures of the lower fatty acids were also found to be inaccurate by means of the same formula and Dr. Arthur Richardson afterwards redetermined these pressures in the Bristol laboratory.

I may mention that Regnault's boiling point of sulphur was subsequently found by Callendar and Griffiths to be too high, and the vapour pressures of mercury had therefore to be again corrected. [Young, *Trans. Chem. Soc.* 59, 629 (1891).] Ramsay accepted my recalculations.

Our investigations of the vapour pressures and volatilising and boiling points of solids and liquids were extended to dissociating substances ['Evaporation and Dissociation,' Pt. I., *Phil. Trans.* 177, 71 (1886)], of which we examined a considerable number—chloral hydrate, butyl-chloral hydrate, chloral methyl-alcoholate chloral ethyl-alcoholate, ammonium carbamate, ammonium chloride, phthalic acid, succinic acid, aldehyde ammonia and nitrogen peroxide. A special form of apparatus was required for nitrogen peroxide on account of its action on mercury, and a special method of calculation for ammonium chloride which acts on mercury at high temperatures. Vapour density determinations were also carried out.

In the case of nitrogen peroxide and ammonium chloride—

and also acetic acid—the curves were of the usual form and the statical and dynamical methods gave the same (or with ammonium chloride nearly the same) results. With aldehyde ammonia both curves were of the usual form, but were quite distinct, the temperatures being much higher on the volatilising point curve. For the other substances the volatilising point curves and in some cases the vapour pressure curves were quite different in form, in fact with the chloral compounds and ammonium carbamate there was no simple relation between volatilising point and pressure. A possible explanation of the peculiar form of some of the vapour pressure curves was given, and it was pointed out that the dissociating substances might be divided into two classes: (*a*) that including such substances as chloral hydrate, in which there is deep-seated chemical change on dissociation, and (*b*) that including nitrogen peroxide and acetic acid and, possibly, ammonium chloride, in which the chemical change is much simpler

Our researches on vapour pressures, volatilising points and boiling points included also an investigation of bromine, iodine and iodine monochloride. [*Trans. Chem. Soc.* 49, 453 (1886).]

A separate paper [*Trans. Chem. Soc.* **49**, 685 (1886)] contained an account of determinations of the vapour densities of chloral ethyl-alcoholate at a series of temperatures and pressures. For this purpose a Hofmann's apparatus was modified in such a manner that pressure, volume and temperature could all be altered at will. The apparatus is described in the *Phil. Trans.* **178**, 57 (1887). We were also led into a controversy with Kahlbaum, who contended that the statical and dynamical methods of determining vapour pressure gave different results. [*Berichte*, **1885**, 2855; **1886**, 69 and 2107.]

Ramsay had already made determinations of the vapour pressures, specific volumes and critical constants of benzene and ether, a copper block being used for heating the substance. [*Proc. Roy. Soc.* **31**, 194 (1880).] Ramsay arrived at the con-

clusion that the molecules of a liquid are more complex than those of the same substance in the gaseous state, and that even above the critical temperature there is a mixture of the two kinds of molecules. The method of heating must, however, have been unsatisfactory, for the observed critical temperature and pressure of benzene were far too high. (Observed 291·7° C.; 60·3 to 60·5 atm., instead of 288·5° C., and 47·9 atm.) The pressure does not appear to have been corrected for the deviation of air (in the manometer) from Boyle's law, but even when this correction is introduced the critical pressure is only lowered to 59·2 to 59·4 atm. (It is possible, of course, that the benzene contained some more volatile impurity which would raise the critical pressure.)

Ramsay invited me to join him in a continuation of these researches. He had employed a vapour bath in his work on specific volumes, the liquid in a small bulb being heated by the vapour of the same substance, boiling under atmospheric pressure. The method of heating in a vapour bath was found to be very satisfactory and was evidently capable of wide application. We decided to adopt it, making use of a series of pure liquids, as already mentioned, and altering the pressure, as required, to give a range of temperature for each substance. The experimental tube could now be placed in a vertical position and the reading of volume was thereby rendered easier and more accurate. The method of filling the experimental tube with liquid in such a manner as to expel the last traces of air was also improved, and curves were drawn from Amagat's data for the correction of pressure for the deviation of air from Boyle's law.

It was perhaps unfortunate that, with the exception of ether, the substances we selected for investigation were hydroxyl compounds—alcohols, acetic acid and, later, water—for these substances are now known to behave abnormally in many respects. Still, the comparison of their properties with those of a large number of normal substances which I afterwards examined has

led to interesting conclusions, and even at that time the results with acetic acid proved to be of considerable interest, especially as a comparison with the data obtained by Natanson with nitrogen peroxide was possible. These two substances, acetic acid and nitrogen peroxide, were found to behave so similarly as regards their vapour densities and, as our own results showed, as regards their vapour pressures and boiling points, that we felt entitled to conclude that the kind of dissociation they undergo must be very similar.

The liquids investigated were methyl, ethyl and propyl alcohol, ether, acetic acid and water. The experimental work was carried out conjointly in Bristol in the case of methyl and ethyl alcohol, ether and acetic acid. The work on propyl alcohol had just been started when Ramsay was appointed Professor of Chemistry at University College, London, and I did the greater part of this work afterwards by myself in Bristol. I also carried out a number of experiments on the mixture of propyl alcohol and water of constant boiling point. The experiments with water were carried out by Ramsay in London, with the exception of those on the vapour densities under low pressures with the modified Hofmann's apparatus, which I made in Bristol.

I may mention in passing that the experiments with propyl alcohol and water led us to the conclusion that the so-called "hydrate of propyl alcohol," described by Chancel, has no existence, and we read a paper on the subject before the Chemical Society in London. Our conclusions, however, were received with scepticism, and the paper was not published in the *Transactions* (Proc. Chem. Soc. 1888). Nine years later Thorpe (*Trans. Chem. Soc.* 71, 920) brought forward evidence against the existence of any of the four 'hydrates of isopropyl alcohol,' described by different observers. Finally, in 1902, a careful study of mixtures of the lower alcohols with water was carried out by Miss E. C. Fortey and myself, and our results, taken in conjunction with those of Konowalow, afford strong evidence that no hydrate of

any alcohol is formed, at any rate at temperatures above 0° C., and in the case of normal propyl alcohol even at $-40°$.

The most important results were those with ether, and with this substance, as also with acetic acid and some of the others, Ramsay and I made a large series of vapour density determinations under low pressures with the modified Hofmann's apparatus, to which reference has already been made. The experimental data for ether were published in the *Trans. Roy. Soc.* **178**, 57 (1887), and the conclusions derived from the investigations as a whole were given in a series of papers:

1. In a letter to the *Phil. Mag.*, June 1887, also *Phil. Mag.* **23**, 129 (1887), we stated our belief that there is normally no distinction, as regards molecular aggregation, between liquid and vapour either above or below the critical temperature. Ramsay's original views on this matter, recently restated by Wroblewski, were thus abandoned, and we found no reason afterwards to change our opinion. [Acetic acid and dissociating substances generally are, of course, exceptional in this respect.]

2. *Phil. Mag.* **23**, 435; **24**, 196 (1887); also *Proc. Roy. Soc.* **42**, 3 (1887). In these papers we announced the discovery that at constant volume the relation between pressure and temperature in the case of ether, both as gas and liquid, is expressed by the simple formula, $p = bT - a$, where b and a are constants, depending on the volume. We gave the values of b and a for a large number of volumes. We also showed that the data obtained by Andrews for carbon dioxide are in agreement with this formula. Barus had independently come to the same conclusion as far as liquids are concerned.

I afterwards found that for iso- and normal pentane the formula is very nearly but not quite true, except at very large volumes and at or near the critical volume.

We also drew the theoretical portions of the isotherms in the region where liquid and vapour ordinarily coexist. We showed how the vapour pressure of a substance (liquid and vapour

coexistent) could be ascertained from the theoretical isotherm (continuous passage from liquid to vapour), and we found that, near the critical temperature at any rate, the theoretical values for ether agreed remarkably well with those observed.

Finally, a comparison of the isochors for nitrogen peroxide and acetic acid with those for ether indicated very clearly the changes $N_2O_4 \rightleftarrows 2NO_2$ and $(C_2H_4O_2)_2 \rightleftarrows 2C_2H_4O_2$.

The difference in behaviour between acetic acid and the other substances was also clearly shown by the curves representing:

(*a*) The relation between the densities of saturated vapour and the temperature (or pressure);

(*b*) The relation between the heats of vaporisation and the temperature.

As regards the first relation, the density of the saturated vapour of ether (taking the density of hydrogen as unity) diminishes with fall of temperature until it becomes normal or very nearly so. This is true also for the alcohols, but the density of the saturated vapour of acetic acid reaches a minimum between 140° and 150°, increasing again at lower temperatures; it was approaching the double value at the lowest temperature at which observations were made.

The heats of vaporisation were calculated from the formula $\frac{L}{v_1 - v_2} = \frac{dp}{dt} \cdot \frac{T}{J}$. The values for ether, methyl alcohol and propyl alcohol were found to increase with fall of temperature and showed no sign of becoming constant. With acetic acid a maximum was reached at about 110°, the heats of vaporisation falling steadily at lower temperatures. For ethyl alcohol no maximum was observed, although from 20° to 0° the values appear to remain practically constant.

The behaviour of acetic acid was explained by us by the fact that there is molecular association both in the liquid state and in that of vapour: the rapid increase in the density of saturated vapour, due to association, at low temperatures accounts for the

fall in the heat of vaporisation. There is no indication of such molecular association in the vapour of any of the alcohols. [*Phil. Mag.* **23**, 129 (1887).]

An investigation on similar lines of a mixture of ethyl alcohol and ether led to results of some interest, but a method of bringing about the thorough admixture of two liquids in a tube of narrow bore by means of an electromagnetic stirrer was afterwards devised by Kuenen, and his results are of far greater value and importance."

In those days experimental scientific research received practically no encouragement at the hands of governing bodies. If a professor chose to engage in work of this kind, it would be done almost surreptitiously in such time as he could snatch from the lecturing and teaching which formed the whole of the official duties connected with his chair. The consequence of this state of opinion, supported as it was by the utterances of public men and the conservative attitude of the older British universities, has been until quite recent years almost total inactivity in regard to research and the higher instruction which is dependent on research in the majority of the universities and colleges in this country. Here and there a man of genius has appeared endowed with sufficient energy to enable him to push onward in spite of such obstacles. Ramsay was one of these, and the record of his work and example has contributed in no small degree toward promoting the change in public feeling in reference to research, which is now almost feverishly manifested.

At Bristol in the early days of the College there were

but few advanced students capable of taking part in research. Among these Miss K. I. Williams, whose death took place in January 1917, deserves to be mentioned. Ramsay suggested to her an investigation into the composition of various foodstuffs, cooked and uncooked, and this enquiry occupied her continued attention till the close of her life thirty-five years later. Her results have been collected into the form of a book, which it is expected will be published very soon. James Tudor Cundall, Colonel H. C. Reynolds, R.E., and Franklin P. Evans also worked at research under Ramsay's direction.

The establishment of the University College brought in the persons of the professors a very welcome accession to the intellectual society of Clifton. Among Ramsay's colleagues were several men who afterwards reached great eminence in their several departments of science. His own immediate colleague, the Lecturer in Chemistry —Dr. Sydney Young—succeeded to the chair when he went to London and afterwards became Professor in the University of Dublin. The Professor of Physics was Silvanus P. Thompson whose fame as a popular lecturer rivalled that of Tyndall at the Royal Institution. A few years later he became Principal and Professor at the City and Guilds of London Technical College, Finsbury. Then there was W. J. Sollas as Professor of Geology and Zoology, now Professor of Geology in the University of Oxford. Engineering was represented by H. S. Hele Shaw, who subsequently occupied

a chair in the Liverpool University and served for some time as Principal of the University College in the Transvaal.

Among the professors on the Arts side were Reginald Fanshaw from New College, Oxford, and James Rowley, Professor of Modern History and English Literature.

The Bristol Medical School of far older foundation, though academically connected with the University College, held for many years a position of financial independence. The names of Greig Smith and Edward Long Fox may be mentioned as of more than local reputation. Dr. John Beddoe, F.R.S., the well-known anthropologist, was also resident in Clifton at this time and is mentioned in several letters of Ramsay's.

Throughout the early years of the new institution the friendly intercourse which existed between the members of the staff and the masters of Clifton College helped to give unity of aim in the higher education of Bristol and to keep touch with men from the older universities. Opportunities of close acquaintance with such men as T. E. Brown, the poet, with Sidney Irwin, W. A. Shenstone, G. H. Wollaston and A. M. Worthington and others were much appreciated by Ramsay[1] and his small

[1] A letter (dated 17th March, 1884) of Ramsay's to his friend Dobbie contains the following passage referring to Worthington: "I sincerely hope that Worthington will be appointed. You will like each other very much. W. is a remarkably nice fellow—in fact an Israelite without guile—as all round as you could wish and really a distinguished physicist in his own line—capillary attraction. His papers have drawn a great deal of attraction—not capillary—at the R.S. and he is bringing out a

staff. Through the members of the College Council also the advantage of intercourse with some of the leading men of business in Bristol was secured to the professorial staff. The great majority of the leading citizens had their residences on the high ground of Clifton and the neighbourhood of the Downs, and thus the best elements in the society of the place were brought by the physical circumstances of the locality near together. The social charm of Ramsay and his wife helped not a little to increase the friendliness pervading the place. A little Browning Society, which had been started by some of the masters at Clifton, afforded opportunities for meeting them and joining them in grappling with the obscurities of Paracelsus and Sordello. Longer lived and possessed of greater vitality was the Scientific Club, which arose out of a previously existing Society meeting at the Museum. Ramsay and Shenstone were the chief promoters of the Club, which met four or five times in the session, and after an informal dinner some member would speak rather than read a paper on any subject which he had made his own. One of these communications from Ramsay was probably the paper "On Smell" printed in *Nature* for 1882. The Bristol Society of Naturalists, of which Ramsay was at one time President,

book on the subject. He is one of my chums here, and I shall be very sorry if he goes. He is at present at Clifton College."

This appears to refer to the Professorship of Physics at Bangor University College, for which, however, Worthington was not chosen. In 1887 he was appointed Professor in the Dockyard School, Portsmouth, and afterwards transferred to the Royal Naval Engineering College, Devonport and Greenwich. He died at the end of 1916.

was the recipient of another paper of his "On Brownian or Pedetic Motion," a subject on which ten years later he communicated his more mature views to the Chemical Society (*Chem. Soc. Proc.* 1892, p. 17).

Many years later, on the twenty-first anniversary of the foundation of the Club, Ramsay was present as a guest and spoke pleasantly and brightly of episodes in its early days. With that kindly twinkle of the eye which with him so often heralded some whimsical touch or paradox, he attributed such success as he had achieved to the great advantage of a bad memory for anything merely read or heard of, and the necessity, in his case, of actual contact with experimental evidence as the window through which the truths of science could alone be perceived. We have the testimony of one who was present on this and other occasions how cordially those who had known him as Principal of University College welcomed him back to Bristol, and a few years later how pleasant it was to join in the ovation given him when he received the Honorary Doctorate of the University, which in large measure owes its existence to what he had done for education in Bristol a quarter of a century before the Charter was granted.

In the early days of the College, writes Professor Lloyd Morgan,

"degrees were only obtainable by sending our students to London University or some other external examining body. But what characterised much of the work of University College was academic teaching on what I regard, I hope without undue

prejudice, as a remarkably high level specially adapted to those, and there were many such at that time, who valued the teaching for its own sake and quite independently of the hall-mark of a degree. I have frequently had occasion to refer to the notes I took of Professor Fanshawe's lectures on Spinoza, to a mere handful of keenly interested students. I question whether a better and more inspiring course of lectures on philosophy was given in any class-room in the United Kingdom. One realised in after-days in what high estimation such teaching was held and how the University College had been regarded as a centre of intellectual atmosphere, for example, if I may cite a case, by the gifted ladies who wrote under the name of 'Michael Field.' In a letter from Sidney Irwin of Clifton College he speaks of Rowley's lectures as bearing the academic stamp of distinction. In all departments such work was encouraged and enlisted Ramsay's sympathy. 'Remember,' he said to me when he was called away to University College, London, 'we are working for the future. We are now a University College, but some day —I hope you may be here to see it—we shall have a University in Bristol. To this end a high level is necessary all round, in Arts no less than in Science.' It was partly through the spirit Ramsay helped to infuse into his colleagues that the prosecution of research was steadily encouraged."

Ramsay frequently visited London either for the purpose of reading his papers before the Royal or the Chemical Society or in connection with social gatherings. On the 23rd of April, 1884, a dinner to Perkin, the discoverer of the first "aniline dye," was given in London under the chairmanship of Hofmann, who had come over from Berlin for the occasion. Many distinguished chemists were present, among them the famous Russian Mendeléeff, of whom the following account by Ramsay,

in a letter to Dr. Blaikie, dated 4th May, 1884, is interesting and characteristic of both :

"I was very early at the dinner and was putting off time, looking at the names of people to be present, when a peculiar foreigner, every hair of whose head acted in independence of every other, came up bowing. I said, 'We are to have a good attendance I think.' He said, 'I do not spik English.' I said, 'Vielleicht sprechen Sie Deutsch?' He replied, 'Ja, ein wenig. Ich bin Mendeléeff.' I did not say, 'Ich bin Ramsay,' but 'Ich heisse Ramsay,' which was perhaps more modest. His method reminded me of 'the only Jones.' Well, we had twenty minutes or so before anyone else turned up and we talked our mutual subject fairly out. He is a nice sort of fellow, but his German is not perfect. He said he was raised in East Siberia and knew no Russian even till he was 17 years old. I suppose he is a Kalmuck, or one of these outlandish creatures."

The origin and early history of University College, Bristol, and other provincial colleges was sketched very briefly at the beginning of the chapter. In a very few years from their foundation most of these colleges found themselves involved more or less in financial difficulties. Their very success was in many cases a source of embarrassment, for not only was it necessary to replace apparatus or fittings which had become obsolete and to provide libraries, but the increased number of students rendered necessary additional teaching assistance. Moreover, colleges which were dependent partly on annual donations and subscriptions found that some of these were apt to silently vanish away, and so for one reason or another nearly all these colleges found themselves face

to face with an annual deficit. This was the case at Bristol, and in the report of the Annual Meeting in November 1884 the treasurer announced that there was a balance on the wrong side of the account amounting to about £500 and that there was a prospect of similar deficiency in the following year. By the year 1885 the Council found it necessary to retrench, and in view of the difficulties Ramsay offered to allow a reduction in his salary as Principal. In the report presented on 17th November, 1886, it was announced that "The Council have had under consideration a proposal that Government should be memorialised for aid to Metropolitan and Provincial Colleges." The history of this movement is given briefly in the following pages. The course of events was followed by Professor Hicks, F.R.S., who, as the former Principal of Firth College, Sheffield, and subsequently Vice-Chancellor of that University, played a leading part in the work necessitated by an appeal for governmental assistance. To him the writer is indebted for many facts which were essential to a continuous record of events.

In 1884 the British Association for the first time met outside the British Isles. Among the party returning from Montreal in the *Peruvian* were the late Professor J. Viriamu Jones, Principal of University College, Cardiff; Professor W. Ramsay, Principal of University College, Bristol; and Professor W. M. Hicks, Principal of Firth College, Sheffield. The Welsh colleges had recently obtained grants from Parliament of £4000 a

year each, and naturally the question of the financial position of their colleges was a subject of frequent discussion among the fellow-travellers on the *Peruvian*. By the end of the voyage it had been determined to bring the matter up at the first meeting of principals, which then arranged should be held in Cambridge during the ensuing Christmas vacation. In a letter to his father, dated 4th January, 1885, Ramsay thus described what took place :

"I was at Cambridge yesterday and attended a dinner of the Principals of all colleges like ours. There were present (beginning from north and coming gradually south) Peterson of Dundee, Garnett of Newcastle, Rendall of Liverpool, Bodington of Leeds, Hicks of Sheffield, Jones of Cardiff, and myself. We had a very pleasant dinner and discussed common subjects with great interest till a very late hour. They put us all up in St. John's College. As I started the idea, they put me in the chair, but it wasn't the least formal, but quite social. The men are queerly divided, for three are professors of physics, two of classics, and myself a chemist, besides one of philosophy. We talk of having it yearly and I think it will be carried out."

The question of Government aid was duly brought up but had a luke-warm reception from some of the chief provincial colleges and the matter dropped, but at the next meeting at Christmas, 1885, it was again discussed. In view, however, of the fact that the members included representatives from the three Welsh colleges who already received grants, and that the three important colleges at Manchester, Liverpool and Leeds held aloof, it was determined by the remainder to call a meeting

of Principals of the English colleges especially for the purpose of considering the whole matter. This meeting was held on 10th April, 1886, at King's College, London. It was a small gathering of five,—Wace (King's College), Tilden (Birmingham), Ramsay (Bristol), Garnett (Newcastle) and Hicks (Sheffield). Dr. Wace was voted to the chair. It was resolved "that it is desirable that steps be taken to obtain from the national exchequer such pecuniary assistance, particularly towards the endowment of chairs and contributions towards scholarships in the existing University Colleges of England as is already enjoyed by similar institutions in other parts of the United Kingdom."

The persons present then formed themselves into a committee to obtain information regarding the finances, staff and students of the various colleges and appointed Professors Hicks and Ramsay to act as honorary secretaries and conveners.

A second meeting was held on 17th June at King's College with the scheduled information before it. The practical outcome of this meeting was the drafting of a letter to be sent to the Councils of all the English colleges enquiring whether they would be disposed to join in an application to the Government for aid, and, if so, to appoint representatives to attend a meeting in London about October, at which the best means of bringing these views before the Government might be considered and definite steps agreed on.

In response to this circular representatives were appointed from Birmingham, Bristol, University and King's Colleges, London, Newcastle, Nottingham, Sheffield and Southampton. Manchester, Liverpool and Leeds sent no representatives, and in fact took no part in the campaign until the end when victory was in sight. The proposed meeting of representatives was held on 6th November, 1886, again at King's College, with Dr. Wace in the chair. As it was felt that a stronger body of public opinion was required, the following resolution was adopted:

"That it is desirable that public meetings be held at the several local centres with a view to a subsequent public meeting in London to be held during the next session of parliament in support of government assistance in aid of higher education."

The meeting definitely requested the governing bodies of the colleges taking part to engage in public action in support of the general principle. But it took some little time to organise and lay the train. A pamphlet was drawn up setting forth the chief facts, the aims of the colleges, their importance for the nation, the necessity for public assistance and specially drawing attention to the fact that while large grants were made to corresponding institutions in Scotland, Ireland and Wales not a single grant was given to the English colleges. Ramsay arranged with Dr. Jowett of Balliol and Sir Henry Roscoe to open the ball by letters to *The Times* and with the *Times* to back up these letters by a

leader. On 13th February, 1887, Ramsay wrote to his mother:

"We have been going on in our usual way, except for the excitement which I have been undergoing in getting people to promise to come to the meeting in favour of Govt. support, which is to be held here on March 2d. I have written to Mundella asking him to come down. I have had a letter from him saying he would do what he could to help us. He can do a great deal. I am sending, with the appeal for state aid, an appeal to the Bristolians to help the college, on the ground that if they don't they won't see much of the Govt. grant when it comes. God helps those who help themselves. I am going to Bath to-morrow to get the Bath people to help us."

Everything being ready the campaign, was opened on 3rd March, 1887, by a long and convincing letter from Dr. Jowett and a warmly supporting leader in *The Times*. The London evening papers of the same day joined in a favouring chorus, and next day the provincial papers spread the cry all over the country.

Roscoe's letter followed and Mundella asked Mr. Goschen (Chancellor of the Exchequer) whether he would assist in the introduction of a measure for granting pecuniary aid to the English colleges. A beginning was thus made and Mundella returned to the charge again on April 19th. Meantime several meetings had been held at Bristol on March 2nd, Southampton March 10th, Sheffield April 12th, and Birmingham May 26th. At Bristol Ramsay was of course present and gave an account of what had been accomplished at the College, the number of students and their subsequent careers.

But he was busy in other ways, as shown by the following extract from a letter to his mother, dated 24th April, 1887 :

"You evidently think that I have been lodging in a den of bishops and such loose characters. Well, the actual fact is that I was asked to give an address on help to Univ. Colleges from Government at a meeting at Oxford last Thursday, to an assembly for promoting University Extension Lectures ;—*i.e.* lectures in all the bigger towns in England on History, Pol. Economy, etc., etc. So Jowett asked me to stay with him at Balliol on Wednesday night and Thursday. So thither I went on Wednesday and met—who do you think ? Terrible nobs. Imprimis, the Marquis of Ripon, who was late Viceroy of India, and who, I daresay you remember, was objected to on the score of his being a Roman Catholic. He is a pursy little man very badly dressed, with a single eyeglass and a fussy manner ; none of the hauteur of the 'ancienne noblesse' about him, but very chatty and affable. Next, the Lord Bishop of London, '✝ Lond.' as he signs his name.[1] He is rather a slow, black-a-vised man in apron and gaiters, but bless you, I am so used to Bishops now that they swarm about me that I pay no attention to their peculiar garb. The prelate's wife is like Mrs. Dods and the Bishop not unlike Marcus,[2] but not so pleasant looking. Then, as if a Catholic peer and an Anglican Bishop were not hotch-potchy enough, we had a real Jew, a Mr. Mocatta, who spoke feelingly of 'my people' and their aims and needs. Minor lights were a Durham Canon and Canoness and a school inspector. My object, duty and pleasure was to convince these people that immediate help was needed for University Colleges, which I am glad to say I did. On

[1] The Rev. Frederick Temple, previously headmaster of Rugby and afterwards Archbishop of Canterbury.

[2] Minister in the Free Church of Scotland and afterwards Free Church Professor of New Testament Theology, Edinburgh.

Wednesday eveg. we had an introductory meeting and on Thursday the Conference took place, followed by a lunch. I spoke at the Conference for about a quarter of an hour, I think pretty decently."

At this time Ramsay was a candidate for the Chemistry Chair at University College, London, about to become vacant by reason of the retirement of Dr. Williamson. To this post Ramsay was appointed at the end of May. He did not, however, slacken his efforts in the cause of the colleges, but rather took advantage of the more frequent opportunities afforded by residence in London of meeting members of parliament and other influential people.

The meeting in Birmingham held on 26th May, 1887, was presided over by the Mayor, Sir Thomas Martineau, and there was a very large attendance. Professor Tilden officiating as secretary read among many others a letter from Mr. Joseph Chamberlain expressing very deep sympathy with the movement. The first resolution was moved by the famous nonconformist minister, the Rev. Dr. Dale, and seconded by Professor Tilden. One point which was brought out in the speeches was the fact that in consequence of the assistance given to the Welsh colleges they were able to reduce their fees to such a low figure that students from Birmingham were attracted away from the college in their own town. It was also shown that the annual deficit on the accounts of the college amounted to about £1500, which included about £500 paid in rates. The college at that time

received no assistance from the municipality, notwithstanding the example of Nottingham, where the college was locally aided from this source.

The letters, discussions and meetings had by this time brought the university question fully to the notice of the public. Consequently at a meeting of the representatives on 21st May, held at King's College, it was resolved (1) to ask Mr. Goschen to receive a deputation and (2) to ask Sir John Lubbock [1] to move a resolution in the House of Commons. The result was that Mr. Goschen consented to receive a deputation on 30th June. A very strong party of practically all the leading men interested in education outside the Government was got together, and constituted with the representatives of the colleges "a very formidable body," as Mr. Goschen said on receiving it. The deputation was introduced by Sir John Lubbock and the chief speakers were Mr. Chamberlain and Mr. Mundella, followed by Sir Lyon Playfair, Sir Bernard Samuelson, Mr. Burt, Professor Tilden, Dr. Percival and Sir George Young. Mr. Goschen, while stating that it would be impossible to deal with the matter by supplementary estimates that year, made it clear that he was interested and that the appeal had his sympathy.

Ramsay, writing to his mother on 11th May, 1887, and referring to what was going on, added: "I feel a little cocky about it, seeing I have engineered it all; but perhaps it is too soon to be cocky yet till we have

[1] Afterwards Lord Avebury.

got the grant." On the 13th June he wrote again, after he had been appointed to University College, and in the course of the letter tells his mother that he has to be in London on the 29th to make final arrangements for the deputation to Mr. Goschen. But it was not till 9th March, 1889, that he was able to write to his mother:

"Do you see that the Government Grant has come at last? It is only £15,000 among all the colleges. It will be in the budget. I don't know how they will divide it, but I hope Bristol will get a good slice. Even £1000 a year would be an infinite relief to them. It would mean comparative affluence. I am also curious to know what our share will amount to."

The communications had been all carried on through Ramsay, and a statement as to the constitution, revenue and students of the colleges concerned had been sent to Sir W. Hart Dyke at the Board of Education. On 11th March, 1888, the National Association for the Promotion of Technical Education had sent a deputation to Viscount Cranbrook, Lord President of the Council, who received it sympathetically, but notwithstanding the favourable auspices nothing further was done that session. But early in February 1889 confidential information was received that a small grant was to be placed on the estimates, and a few days later a committee was appointed by the Treasury to enquire into the best way of apportioning the grant among the colleges. On 1st July, 1889, the Treasury practically adopted the recommendations of the committee and the battle was

won. The grant was almost absurdly small, but a great point was gained in the recognition of the principle of state aid for the university colleges. The local prestige thus gained by the college was almost as important as the money value of the grant, and to obtain an increase appeared only a matter of time. In fact, before two years were over the agitation for an increase began. In this further movement Ramsay, though no longer Principal of a college, took a very active part, and the influence which he exerted throughout must be counted among his great services to science. The present position of the new universities, which have developed from the colleges, is a result of the recognition of the principles for which he fought.

LIST OF PAPERS BY RAMSAY AND YOUNG.

1. Trans. Chem. Soc. **45**, 88 (1884). The Decomposition of Ammonia by Heat.
2. Trans. Roy. Soc. **175**, 37 (1884). The Influence of Pressure on the Temperature of Volatilisation of Solids.
3. Trans. Roy. Soc. **175**, 461 (1884). Influence of Change of Condition from the Liquid to the Solid State on Vapour-pressure.
4. Trans. Chem. Soc. **47**, 42 (1885). On a New Method of Determining the Vapour-pressures of Solids and Liquids, and on the Vapour Pressure of Acetic Acid.
5. Trans. Chem. Soc. **47**, 640 (1885). A Method for obtaining Constant Temperatures.
6. Berichte, **18**, 2855 (1885). Ueber die sogenannte "Specifische Remission von Kahlbaum."

7. Berichte, **19**, 69 (1886). Ergeben die statische und die dynamische Methode der Dampfspannkrafts-messungen verschiedene Resultate?

8. Berichte, **19**, 2107 (1886). Ueber die statische und dynamische Methode der Dampfdruck-messungen.

9. Brit. Assoc. Report, **1885** (Aberdeen). Some Thermodynamical Relations.

10-14. Phil. Mag., Series V., **20**, 515 (1885); **21**, 33 and 135; **22**, 32 and 37 (1886). Some Thermodynamical Relations.

15. Trans. Chem. Soc. **49**, 37 (1886). On the Vapour-pressures of Mercury.

16. Trans. Chem. Soc. **49**, 453 (1886). On the Vapour-pressures of Bromine and Iodine and on Iodine Monochloride.

17. Trans. Chem. Soc. **49**, 685 (1886). Note on the Vapour Densities of Chloral Ethyl-alcoholate.

18. Journ. Soc. Chem. Industry, **5**, 232 (1886). Decomposition of Chloroform at Red Heat.

19. Trans. Roy. Soc. **177**, 71 (1886). On Evaporation and Dissociation, Pt. I.

20. Trans. Roy. Soc. **177**, 123 (1886). On Evaporation and Dissociation, Pt. II. A Study of the Thermal Properties of Alcohol.

21. Trans. Roy. Soc. **178**, 57 (1887). On Evaporation and Dissociation, Pt. III. A Study of the Thermal Properties of Ethyl Oxide.

22. Trans. Chem. Soc. **49**, 790 (1886). On Evaporation and Dissociation, Pt. IV. A Study of the Thermal Properties of Acetic Acid.

23. Trans. Roy. Soc. **178**, 313 (1887). On Evaporation and Dissociation, Pt. V. A Study of the Thermal Properties of Methyl Alcohol.

24. Phil. Mag., Series V., **23**, 61 (1887). Influence of Change of Condition from the Liquid to the Solid State on Vapour-pressure.

25. Phil. Mag., Series V., **23**, 129 (1887). On the Nature of Liquids, as shown by a Study of the Thermal Properties of Stable and Dissociable Bodies.

26. Phil. Mag., Series V., **23**, 547 (1887). On the Gaseous and Liquid States of Matter.

27. Proc. Roy. Soc. **42**, 3 (1887). Note on the Continuity of the Gaseous and Liquid States of Matter.

28 and 29. Phil. Mag., Series V., **23**, 435; **24**, 196. On Evaporation and Dissociation, Pt. VI. On the Continuous Transition from the Liquid to the Gaseous State of Matter at all Temperatures.

30. Trans. Chem. Soc. **51**, 755 (1887). On Evaporation and Dissociation, Pt. VII. A Study of the Thermal Properties of a Mixture of Ethyl Alcohol and Ethyl Oxide.

31. Zeitschr. für physik. Chemie, **1**, 237 (1887). Studien über Verdampfung und Dissociation.

32. Trans. Roy. Soc. **180**, 137 (1889). On Evaporation and Dissociation, Pt. VIII. A Study of the Thermal Properties of Propyl Alcohol.

33. Proc. Chem. Soc. **1888**. Note on the Mixture of Propyl Alcohol and Water of Constant Boiling-point.

34. Trans. Roy. Soc. **183**, 107 (1892). On Some of the Properties of Water and of Steam.

35. Trans. Roy. Soc. **186**, 257 (1895). On the Vapour-pressures of Argon.

CHAPTER IV

UNIVERSITY COLLEGE, LONDON. 1887 TO 1894

It is unnecessary in these pages to relate the history o the college and university to which, in 1887, Ramsay was called. But it is necessary to recall the fact tha the chair of chemistry in University College had beei occupied from the first by professors of the highes rank and of world-wide reputation. The first occupan of the chair was Edward Turner, F.R.S., the author o a work, *The Elements of Chemistry*, which in its day wa regarded as authoritative. He died in 1837 and wa succeeded by Thomas Graham. Graham's name i famous in the history of chemistry, for until quit recent times existing knowledge of gaseous and liquic diffusion and the phenomena connected with the ab- sorption of gases by colloids and by metals was derived entirely from Graham's experimental researches. Graham was the first President of the Chemical Society, which was founded in 1841. In 1855 his connection with the College came to an end, as he was appointed to succeed Sir John Herschel as Master of the Mint. But a few years earlier, while continuing his lectures, the practical

chemistry instruction in the laboratory was relinquished by him and was placed under the direction of George Fownes, F.R.S., then Professor of Chemistry to the Pharmaceutical Society. Fownes did a good deal of interesting experimental research, but the work by which he was known to many generations of students was his familiar *Manual of Chemistry*, which in one volume provided all the instruction in physics, as well as inorganic and organic chemistry, which in those days was regarded as sufficient for the majority. Fownes died in 1849 and was succeeded by Alexander Williamson, who six years later was appointed to the chair of chemistry on the resignation of Graham. Williamson was known personally to many of the present generation, and there are still among us a not inconsiderable number of his students. Williamson, like Graham, was a philosophical chemist, whose mind was occupied with deep and broad views concerning the constitution of matter and the nature of chemical action. Williamson's most famous experimental research related to the constitution of the ethers and involved his favourite ideas concerning atomic movement. The theory of types has long since gone the way of all theories, but in its day the introduction of the *water type* by Williamson was an event of first-rate importance, which facilitated the classification of many compounds and reactions. It was immediately adopted into use by the most active of the contemporary chemists, of whom Gerhardt, Odling and Kekulé were among the most distinguished. Williamson's influence

as a teacher was considerable, but his activity in connection with the establishment of science degrees in the University, and in administrative work both within and without the College during the later years of his tenure of the chair, led to the practical abandonment of experimental research and the personal supervision of the laboratory instruction.

One other name must be mentioned, that of Charles Graham, who, after working for a time as assistant under Williamson, was in 1878 appointed Professor of Chemical Technology in University College. He achieved a considerable reputation in connection with the science and technology of brewing and malting. He retired in 1889, and subsequently carried on for about ten years a private consulting practice chiefly in connection with fermentation industries.

The chair to which Ramsay succeeded was therefore furnished with traditions. The successive occupants had always been among the leaders of scientific progress, and the responsibilities connected with the post might have been ground for anxiety. But the new professor had already won his spurs, and was confident in his own powers. Almost immediately after entering on his new duties (in 1888) he was chosen one of the fifteen for the F.R.S. We shall see later how the anticipations of his friends were fulfilled, though no one could have expected the discoveries which followed so rapidly a few years later.

Work at University College was begun under peculiar

and somewhat disagreeable circumstances, for Ramsay found in the laboratories the accumulated residues of forty years. Professor Williamson seems never to have allowed anything to be thrown away, and the remains of, for example, the preparation of chlorine had been stored in dozens of jars and bottles with what object no one can now explain. There were also hundreds of paper packages covered with dust and without labels, all of which, amounting to several cart-loads, had to be, examined and cleared away by the new professor and the new assistant whom he had invited to join him.[1]

The students were chiefly medical, and very large classes were preparing for the examination of the Conjoint Board. In the general laboratory there were only about half-a-dozen, but there was another laboratory, the Birkbeck Laboratory[2] for Chemical Technology, occupied by Dr. Graham. This occupation, however, came to an end two years later when Dr. Graham retired and the laboratory was then devoted to the use of pathology and botany. Mr. Watson Smith was then appointed to succeed Graham, merely as Lecturer in Chemical Technology. This lectureship was abolished in 1894.

[1] J. Norman Collie had been engaged in teaching chemistry at the Ladies College, Cheltenham. He came up to University College in October 1887, and, with the exception of six years (from 1896 to 1902) as Professor to the Pharmaceutical Society, he has remained ever since. Since 1902 Dr. Collie has been University Professor of Organic Chemistry.

[2] Founded in memory of Dr. Birkbeck.

When Ramsay first came to University College th number of lectures to be given was very great, as women medical students and others had separate lecture course and consequently the same *preliminary lectures* had t be given three times over in the session. At this tim the Assistant Professor of Chemistry (apart from Tech nology) was Dr. Richard T. Plimpton. Ramsay wa fortunate in having such a man as Dr. Plimpton a chief assistant when he first came. Plimpton was first-rate teacher, and many of the students of thos early days owe a great debt to him for the excellen grounding he gave them in analytical chemistry.[1]

After Ramsay's first session at University College th women students, for whom separate instruction in chemistry had previously been given, were admitted t the same lectures as the men. This was quite in accord ance with Ramsay's views about the position of women in relation to science. And a few years later, when a somewhat acute controversy arose in the Chemica Society on the subject of admitting women, Ramsay wa of the party which would have opened the door to women as well as men on precisely equal terms.

The two assistants at University College in 1887 were Dr. Samuel Rideal and Dr. J. N. Collie. An additiona assistant was not appointed till 1891, when Mr. C. F Baker, B.Sc., was chosen. He was succeeded in 189 by Mr. H. W. Picton, B.Sc., and both were replaced

[1] In 1894 Plimpton was appointed Lecturer on Chemistry at the Middlesex Hospital Medical School. He died suddenly on 21st December, 1899.

the following year by Dr. James Walker and Mr. Alexander Kellas, B.Sc. In 1894 Mr. Morris Travers became assistant in place of Dr. Walker.

In the early days Ramsay was perpetually in the general laboratory and knew all about every student there. Often while talking to a student he would suggest to him to make experiments for himself in order to solve difficulties. This was not always acceptable to the assistants who, with the fear of the examinations before their eyes, were anxious for the students to stick to their systematic work. Ramsay always encouraged students to practice glass-blowing as much as possible. One learned professor, coming into the laboratory, remarked to Ramsay, "Do you allow your students to waste their time over that sort of thing? It can be done far better by the professional glass-blower."

Ramsay was very popular with the students. Every year, at the end of the first term, a dinner was arranged by the laboratory students and the practice has been kept up ever since. At these dinners Ramsay was the moving spirit, making speeches, singing songs, whistling and joking with everyone. Students, after leaving, often came back to these gatherings whenever they had a chance, and at the last dinner before the war there were present men who had left University College as much as twenty-five years previously.

As soon as laboratories for instruction in practical chemistry were erected, the methods of instruction to be employed had to be considered and reduced to some

kind of system. The first laboratory opened for this purpose was at Bloomsbury Square on the premises still occupied by the Pharmaceutical Society. Almost immediately after this, in 1845, the Royal College of Chemistry was founded and A. W. Hofmann was the first professor. At the former institution the first operations in which the student was engaged consisted in preparing and crystallising a number of metallic salts and other compounds. In a few weeks or months he was instructed in qualitative and simple quantitative analysis. At the College of Chemistry, on the other hand, the whole of the first year was occupied with qualitative analysis. The second year was devoted to quantitative analysis and the student was then allowed for the first time to engage in making preparations, which business was always associated with some kind of research. This was the order usually adopted in the great majority of laboratories on the continent as well as in this country during the next thirty years or more, and was probably the system practically at work in the chemical laboratories at University College when Williamson resigned and Ramsay succeeded him. Other teachers have advocated the introduction of the student to methods of research from the outset, but as science has progressed very far since the middle of the nineteenth century there are not only the transformations and extensions of theory to be considered, but the material, apparatus and methods used in the modern laboratory are far more complicated than those of fifty years ago.

Hence if a student is engaged too soon in attempts to find out some new thing, he is perpetually finding obstacles in the way of progress owing to want of knowledge or of skill. As to the degree of preparation necessary for success in research, there will always be some difference of opinion.

Ramsay was face to face with the necessity for determining on the method he would use in the teaching of chemistry so soon as he obtained his first independent appointment and that was at Bristol in 1880. The method he contrived was set forth in a little book, published in 1884, under the title *Experimental Proofs of Chemical Theory for Beginners.* The following extracts from the Preface sufficiently describe its scope and object:

"The experiments described in this little book have formed the preliminary work of all students beginning chemistry in my laboratory for the last two years. I am convinced that such a course has the advantage of familiarising the student with the subjects treated in the first term of an ordinary course of lectures; of giving him practice in the construction of apparatus; and of making him perform calculations with a definite object, instead of as merely theoretical problems.

I have not found any difficulty in getting students to construct their own apparatus; after a few preliminary lessons in cork-boring, bending glass tubes, etc., the demonstrator is put to little trouble. . . . The accuracy of the results obtained by these comparatively rough methods is surprising; the density of gases is found usually within three of four per cent. of the truth; and results of analysis seldom show an error of one per cent. Of course good results are obtained only by careful workers,

and I make it a rule that each experiment shall be repeated until a satisfactory result is obtained. The whole course occupies a term of ten weeks, the student working three whole days a week."

Longer experience, however, does not appear to have confirmed the efficacy of this system, for on commencing work at University College, London, the book fell into disuse. We have it on the evidence of one of his students at this time, Mr. E. C. C. Baly, who remained at the College for twenty-two years and became one of the assistant professors, that the students were "thoroughly grounded in qualitative analysis first of all, and this was followed by an admirable course in quantitative work." "Ramsay was a strong believer in the value of analysis, qualitative and quantitative as a method of training. He gave the proofs of theory in lectures which were very remarkable for their wealth of experiments, well conceived and admirably discussed."

The days when the habits and manners of Mr. Bob Sawyer represented those of medical students in general have long since passed away. But down to a very late period in the nineteenth century disorder was rather prevalent in many classes of medical students, especially in connection with purely scientific subjects such as chemistry. While this was in some cases due to want of firmness on the part of the teachers, it was chiefly attributable to the laxity of the several medical examination Boards in reference to chemistry. When Ramsay came to University College the general chemical lectures were

the scene of the usual "bear-garden." By the end of the first term, however, he reduced the class to order and never afterwards had further trouble.

With regard to the purely chemical students Ramsay was always anxious to encourage original investigation and in many cases allowed them to enter on research before they had secured the Bachelor degree. This naturally interfered with their general reading, and as candidates at the degree examination they sometimes did badly. But the following extract from a letter to Professor Worthington, dated 12th November, 1888, shows what was Ramsay's own state of mind: "My classes are in good order and work well. I am therefore happy so far as they go. We have just had five men through the B.Sc. Of these four are going in for honours next week, and when they have been sufficiently tortured, they will begin research. So now we are in a fair way to get a 'school.'" This letter was dated from "12 Arundel Gardens, W.," which was to be the home of the Ramsays, with their two children, for some fifteen years.

The following year Worthington was Professor of Physics in the Royal Naval Engineering College, Devonport, and negotiations were started with the object of joint holiday arrangements between the two families. On 30th June, 1889, Ramsay wrote:

"The order of nature should have been so adjusted that our holidays might fall contemporaneously. You must get them to alter. Ours are like the holidays of the Medes and Persians. By

the way, did the Ancients ever have holidays? I imagine not. I think they merely took things easier all round.

Anyhow I am now an instructor of medical youth, and so have to keep their terms, which means that I go on till July 20th and then stop till October 1st, when I again repeat the wondrous tale. They are an unsatisfactory style of people, having regard to their exams. more than their instruction. It is as if one paid more attention to the ejecta than the injecta; as if all the pleasure were in having a tooth drawn not in making use of a sound molar. However, our nation is being radically corrupted. The natural mind is enmity against wisdom, knowledge and all instruction. It occurs to me that I quote in a mangled form from Proverbs. It might not be a bad thing to begin one's lectures with a few homilies on the sayings of Solomon. He was pretty well up in human nature, that old wiseacre, and has left on record many quaint and pithy sayings *virginibus puerisque*. . . . What are your results with the breaking strain of liquids? I have just got rid of the molecular weights of metals and am glad to be done with it. I am now preparing for an onslaught on vacua and am having my private-room fitted up as a laboratory."

The research mentioned was embodied in a paper on "The Molecular Weights of the Metals," published in the *Transactions of the Chemical Society* for 1889 (p. 521). The method adopted was the estimation of the depression of the vapour pressure of mercury by dissolution in it of a known quantity of the metal. The results obtained led to the somewhat unexpected conclusion that in solution as a rule the molecules of metals are composed of single atoms. This, however, agrees with the usual view as to the constitution of those metals of which the vapour densities have been determined, namely

mercury, cadmium and zinc, and these are all undoubtedly monatomic.

Before leaving Bristol Ramsay had occupied himself in conjunction with Mr. J. Tudor Cundall with a study of the oxides of nitrogen, and more particularly with the singularly elusive substance supposed to consist of the trioxide. Apart from the desirability of ascertaining definitely the physical and chemical properties of both the peroxide and the trioxide the part played by the gaseous oxides of nitrogen in the reactions which go on in the production of sulphuric acid in the lead chamber was and is still sufficiently mysterious to render further research very desirable. The first paper by Ramsay and Cundall is in the *Transactions of the Chemical Society* for 1885 (p. 187). It seems chiefly to bring out the fact that the blue or green liquids supposed to contain the trioxide consist of mixtures of N_2O_4 and N_2O_3 both in a partially dissociated state and that the passage of nitric oxide, NO, into this liquid fails to convert it wholly into N_2O_3, while the addition of excess of oxygen similarly fails to convert it completely into the peroxide.

This communication elicited two papers from Dr. G. Lunge, whose great experience in the manufacture of sulphuric acid entitles an expression of his views to respect. In these papers he endeavoured to prove by argument and by some experiments that nitrous anhydride, that is nitrogen trioxide, is capable of existing in the gaseous state. In a second paper (p. 672 in the

same volume) Ramsay and Cundall proved by ingenious experiments that *gaseous* nitric peroxide does not combine at ordinary temperatures with nitric oxide, also that the density of the gas produced when blue liquid nitrogen trioxide is allowed to evaporate was found to be 22·35 at ordinary atmospheric conditions. This corresponds to the calculated density of a mixture of NO_2 and N_2O_4 with NO and renders the assumption of the presence of N_2O_3 highly improbable.

Ramsay returned to the question three years later. The method of estimating molecular weights by observing the depression of the freezing point introduced by Professor Raoult of Grenoble had recently attracted deservedly increased attention.

In a paper in the *Transactions of the Chemical Society* for 1888 (p. 621) Ramsay showed by this method, using acetic acid as the solvent, that nitric peroxide in the *liquid* state is represented by the formula N_2O_4. The trioxide was found to be unmanageable owing to its instability. But Ramsay took up the question again, and another paper appears in the *Transactions* for 1890 (p. 590), in which a fuller account is given of both these oxides of nitrogen, and the probability that the trioxide in the *liquid* state is correctly expressed by N_2O_3 is converted into certainty. It appears to undergo dissociation to some extent even at $-90°$. With regard to a mixture of the oxides of nitrogen in the gaseous state it seems to have been shown by Dixon and Peterkin some years later that a *small* quantity of N_2O_3 may exist in

such a mixture in an undissociated condition (*Transactions Chem. Soc.* 1899, p. 613). This is quite consistent with the results of Ramsay and Cundall.

In 1890 the British Association met at Leeds, and the proceedings of the Chemical Section were enriched by a discussion in which the supporters of the older views as to the nature of solutions and of the newer doctrines were both present and took part. The reader may be reminded that up to quite recent times the nature of the process involved, when a soluble substance such as common salt or sugar dissolves in water, had not been studied systematically and it had been very generally assumed that when a solid substance dissolves in a liquid a weak kind of chemical combination occurs between the solid and the liquid. This was usually referred to broadly as the *hydrate theory* of solution, and there can be no doubt of the existence of many hydrates in salt solutions and of compounds of the solute in the solvent in other cases in which liquids other than water are concerned. But the electrolytic and other properties of solutions cannot be accounted for by the hydrate theory, and it was not till 1887 that the new view of the constitution of solutions was introduced, by which many difficulties were explained. In that year the Dutch Professor Van't Hoff published in the *Zeitschrift für physikalische Chemie* a theory based on the analogy between the state of substances when in solution and the same when in the state of gas. The dissolved substance exercises a pressure, called osmotic

pressure, which leads to the assumption that the mo
cules of the dissolved substance subsist in the liquid
the same number in unit volume and exert the sa
pressure as they would if they were capable of assumi
the state of gas at the same temperature. This paper w
immediately afterwards translated by Ramsay and pu
lished in the *Philosophical Magazine.* This theory
Van't Hoff's was found not to be equally applicable
substances like common sugar on the one hand, and
the other to salts and compounds of saline constituti
such as acids, all of which are electrolytes. And t
next step was represented by the hypothesis of Arrheni
published in 1888, as to the dissociation of such co
pounds into their chemically interchangeable parts
ions. This hypothesis to the supporters of the ol
doctrine seemed to be contrary to fact and comm
sense. It may readily be imagined therefore w
what animation the discussion proceeded in the jo
meetings of Sections A and B. A report of the seve
speeches was published in the *Chemical News* and
the Abstracts issued by the Chemical Society, But
so often remarked, the discussions which take place
public on such occasions are often equalled or surpass
in practical effect by the more intimate and inform
talk which goes on over the dinner-table or perhaps
the garden or over a pipe at night. One such sy
posium occurred at Leeds in the house of Profes
Smithells, who has kindly supplied the following n
recording his recollections of what took place :

"The Leeds Meeting of the British Association in 1890 is memorable as marking the first Ionic invasion of England in the persons of van't Hoff and Ostwald. It was, of course, in the early days of the ionic theory of solution and I remember Ostwald remarking that the united ages of himself, van't Hoff and Arrhenius were then less than a hundred years.

Ramsay and Ostwald met for the first time as fellow-guests in my house, which became accordingly a sort of cyclonic centre of the polemical storm that raged during the whole week. No meeting within my experience has more fully illustrated the fact that the most interesting and stimulating proceedings of the British Association are those which occur outside the section rooms. The discussion was, as I have said, incessant. I remember conducting a party to Fountains Abbey on the Saturday and hearing nothing but talk of the ionic theory amid the beauties of Studley Royal. The climax, however, was reached the next day—Sunday. The discussion began at luncheon when Fitzgerald raised the question of the molecular integrity of the salt in the soup and walked round the table with a diagram to confound van't Hoff and Ostwald. After luncheon the party adjourned to the garden and was gradually increased by the arrival of strolling philosophers until it assumed quite large proportions. I regret that at this distance of time I cannot recall the names, but I believe it included, in addition to Ramsay and those named, Lodge, Armstrong, Pickering, Otto Pettersson, and there were others.

The discussion continued throughout the afternoon with alternating vehemence and hilarity. I have a particular recollection of Fitzgerald walking restlessly about with his hand clasped on his brow and declaring in his rich Irish brogue, 'I *can't* see where the energy comes from.' Ramsay, as you can imagine, was no silent spectator. Being a convinced ionist, he was eager in helping out the expositions of Ostwald, whose

English at that time was imperfect and explosive, and his wi and humour played over the whole proceedings. I wish I coul do more justice to him and to the occasion. I believe it effecte a good deal towards forming friendships, promoting good wil and removing misunderstandings, and certainly it was the begin ning of relations of great mutual sympathy and regard betwee Ramsay and Ostwald, which lasted till they were divided b their respective national sympathies at the unhappy outbrea of war."

So long as nearly forty years ago the subject o Brownian or pedetic motion attracted Ramsay's notice and in 1882 he communicated to the Bristol Society o Naturalists a short paper on the subject. This curious phenomenon was first described by the botanist Robert Brown (b. 1773—d. 1858) in the course of his observations on the pollen of plants and was at first attributed to life in the moving mass. When a muddy solution or an emulsion like milk is examined under the microscope the suspended particles, if small enough, are seen to be in motion constantly but irregularly both as to direction and speed. The motion is not related to the composition of the particles, but only to their size and specific gravity and the nature of the liquid. The motion cannot be attributed to currents in the liquid, for no two particles move in the same direction or with the same velocity. In 1892 Ramsay brought the subject before the Chemical Society. By this time some important experimental work had been done especially by Messrs. Linder and Picton at University College, who had shown that they are apparently charged

electrically, for they are attracted or repelled, according to their nature, from one or other of the electrodes converging a current into the liquid in which the particles are suspended. During the twenty-five years which have elapsed since 1892 much has been done by various observers and especially by Professor Jean Perrin of the Sorbonne, and it is now pretty generally the custom to attribute these movements to the motion of the molecules of the liquid in which the particles are suspended. In 1882 Ramsay, in considering this hypothesis, appeared to think that single molecules could have no effect on masses so many million times larger than themselves, as the moving particles are, and that to produce an effect many molecules must coalesce and move as a whole. In 1892 he seems to have retained practically the same view and supposed that the effect of adding an electrolyte to a liquid in stopping pedesis is due to the breaking up of these molecular aggregates by the presence of ions.

From the first, on coming to London, Ramsay busied himself with the idea of a Teaching University for London, and to his exertions some of the changes which were afterwards introduced into the method of conducting the examinations of the University, so as to give the teachers a larger share in determining the places of the candidates, were doubtless in part due. On June 8th and 9th, 1892, two articles from his pen were printed in *The Times* under the heading "Universities Abroad," and from

these the following introductory remarks may be quote here:

"The last 10 or 15 years have witnessed great changes in th attitude of the English people towards education. Elementar education has been made first compulsory, then free; th endowments and efficiency of grammar schools have been sub jected to close scrutiny; it has been decided that a sum of n less than £538,600 shall be yearly spent on technical instructio in England alone; local University colleges have sprung u in almost all the large cities of the kingdom; three of thes —Owens College (of older foundation), University College Liverpool, and the Yorkshire College of Science, Leeds—hav acquired *status* as the Victoria University; a sum of £15,00 a year is granted by Government for the partial maintenanc of the metropolitan and local colleges, with prospect of materia increase at no distant date; a Royal Commission has recentl issued recommendations involving a radical change in the constitution of the Scottish Universities; and lastly, and latest in order of events, a scheme has been approved by the Privy Council for the establishment of a Teaching University in London. The 'Gresham Charter,' however, having failed to command the concurrence of the House of Commons, a New Royal Commission is at present deliberating on the best means of uniting under one head the institutions in London which give education of University standard.

In other European countries there is at present no such educational turmoil. The systems of primary and secondary education have long ago been elaborated; and the Universities pursue the smooth paths of increasing knowledge by research and by the training of students.

Recent correspondence and articles which have appeared in the public Press show that there are in England many conceptions of what a University should be. Many of the writers appear to consider a college as necessarily a hall of residence,

as in Oxford or Cambridge; many suppose the primary function of a University to consist in bestowing degrees after a certain course of study; while others advocate the claims of a 'University for the People,' where weekly evening lectures should lead to recognition of the students as eligible for an associateship or for a degree. There are yet others who imply that the function of a University consists in examination only, and who uphold the University of London as an ideal institution.

In this state of public opinion it is well to cast our eyes abroad, and to enquire what conception of a University is held by the nations of the Continent. Before beginning an experiment it is advisable to study the literature of the subject, for thus only can errors be avoided and a reasonable prospect of a successful issue secured. This is the invariable prelude in these days to all scientific inquiry, and surely the most important of all is—How can knowledge best be increased?"

Ramsay was less interested in questions relating to University organisation and government than in the regulations under which degrees are obtained. These are the questions which affect most directly the system of teaching and which have probably had as much to do with the tendency on the part of English and American students to seek admission to continental universities as the eminent reputation of the professors in the majority of these institutions.

Though these articles were written twenty-five years ago they still represent the constitution and operation of the universities referred to in all respects which may be regarded as fundamental, though in some details there have been modifications.

The continental universities agree in their conditions

for granting degrees in several points, in which they differ from English universities generally.

Thus the preparation of a Thesis or Dissertation is the essential qualification for a degree and is not replaceable by any examination or series of examinations. The thesis embodies the results of work done by the candidate and always professes to be based on research, experimental, historical or literary, etc. As a matter of practice the subject is always selected, or at least approved, by the professor under whose direction the student works. After the dissertation has been presented and accepted by the Faculty, an examination, sometimes written but usually oral, follows on the subject of the dissertation and other subjects cognate to it. The examiners are the teachers of the candidate associated with other members of the Faculty.

Something of this kind was what Ramsay desired to see introduced generally into the universities of this country. "How can knowledge best be increased?" was the question ever before his mind, and in his own ardour for research into the unknown he seems to have attached less importance to those other functions of universities which are connected with preparation for professions and for the everyday life of the world. Probably his view would have been that initiation into the methods of scientific research is the best preparation for successful investigation of the problems which come before the physician, the engineer, the agriculturist, the teacher, the man of business no less than the man who

takes up natural science as a pursuit to be followed through a lifetime. And his distrust of examinations and their results as a means of discovering capacity or rewarding merit often brought him into conflict with those who rely more confidently on the utility of examinations as an educational instrument. This is a large question of far-reaching importance upon which unanimity can never be expected. Even in Germany there is great difference of opinion among the professors in the universities as to the desirability of increasing the number and the stringency of examinations leading to the doctor's degree.[1]

Men of genius like Ramsay are apt to forget, if they become teachers, that the average quality of mind among students is very different from their own, and attempts to apply indiscriminately methods which appeal to their own mental activity and resource are certain to meet with disappointment in the great majority of cases. It is, in fact, too often forgotten not only by teachers but by parents and others that though a natural faculty may be improved by education, it can never be created by any process in those cases where the natural faculty does not already exist. Poets, mathematicians, researchers are born, not made, and all that education can do in any case is to educe, train and strengthen qualities already existent which might otherwise run to waste and produce merely mischief.

[1] Bailey Saunders, *Notes addressed to the U.L. Commissioners*, Jan. 1899.

CHAPTER V

THE GASES OF THE ATMOSPHERE

THE last twenty years of the nineteenth century witnessed two discoveries in physical science, namely the observation of X rays and the isolation of the argon series of gases, which equal, if they do not surpass, in significance and interest the discoveries of any previous period. Of the two the latter must be regarded as the most surprising, because it was not only unexpected, but the existing evidence would have appeared conclusive against the possibility of such a discovery as that of a new unheard-of constituent of our atmosphere. It is, however, an interesting illustration of a statement made by Lord Kelvin in his Presidential Address to the British Association in 1871: "Accurate and minute measurement seems to the non-scientific imagination a less lofty and dignified work than looking for something new. But nearly all the grandest discoveries of science have been but the rewards of accurate measurement and patient long-continued labour in the minute sifting of numerical results." For the discovery originated in the laborious and accurate determination by Lord Ray

leigh of the relative densities of the principal gases, an investigation which extended over some twelve years, commencing in 1882. In that year Rayleigh had called attention to the statement which had so long passed under the name of Prout's Law. According to this statement the atomic weights and hence the densities of the simple gases stand in a simple numerical relationship to the atomic weight and density of hydrogen. The first result of this investigation was the demonstration that the atomic weight of oxygen is approximately 15·8 and therefore less than the whole number 16 required by Prout's "law," which was thus shown to be illusory.

Unexpected difficulties were encountered in dealing with nitrogen gas, but the upshot of the numerous experiments undertaken was the discovery that the gas left when oxygen, water vapour and carbon dioxide were completely removed from atmospheric air was appreciably heavier than nitrogen prepared from ammonia by passing a mixture of this gas with air or oxygen over a surface of heated copper.

With reference to this anomaly Lord Rayleigh addressed a letter to *Nature* on 29th Sept., 1892, in which the following passage occurs:

"I am much puzzled by some recent results as to the density of nitrogen and shall be obliged if any of your chemical readers can offer suggestions as to the cause. According to two methods of preparation I obtain quite distinct values. The relative difference, amounting to about $\frac{1}{1000}$ part, is small in itself; but it lies entirely outside the errors of experiment, and can only be attributed to a variation in the character of the gas."

The ammonia method of preparation had been su gested to him by Professor Ramsay.

A paper on the subject, under the title "An Anoma encountered in the Determinations of the Density Nitrogen Gas," by Lord Rayleigh, was published in tl *Proceedings of the Royal Society* in April 1894. In th paper the author discussed the difficult question as the possible impurities in atmospheric nitrogen whic would account for its apparent greater density, and, c the other hand, the impurities lighter than nitroge which conceivably might be present in the gas derive from chemical sources.

As to the gas obtained from air it was shown coı clusively that the superior density could not be attr buted to the presence of unabsorbed oxygen.

Of the gases lighter than nitrogen the presence (water vapour or ammonia could be dismissed froı consideration at once, in view of the conditions unde which the experiments were conducted. The only ga which required special attention was hydrogen, but thi and such light hydrocarbons as marsh gas would b removed by the hot copper oxide over which the gas i made to travel. An experiment in which hydrogen wa purposely introduced proved in fact that it was com pletely burnt out by this treatment.

Other experiments followed in which nitrogen obtaine by removing oxygen from the oxides of nitrogen b means of heated iron was compared with nitrogeı derived from air by the absorption of oxygen by mean

of hot iron or in the cold by means of ferrous hydrate. The same difference of density was again observed. Storage of the chemically prepared nitrogen for many months or exposing it to the effect of the silent electric discharge produced no effect on the density of chemical nitrogen and the hypothesis that such nitrogen might be in a condition in which some of its molecules, N_2, were dissociated into atoms had to be abandoned.

Early in 1894 the position was therefore as follows: it had been abundantly proved that nitrogen derived from the air by absorption and removal of the other known constituents of air is heavier by about $\frac{1}{230}$ than nitrogen obtained by the decomposition of chemical compounds. It had also been shown that the apparent lightness of the latter was not due to the presence of lighter impurities nor to dissociation. The only possible hypothesis remaining was that atmospheric nitrogen was mixed with a small quantity of a heavier gas, the nature of which was unknown.

About this time Lord Rayleigh's attention was drawn [1] to the work of Cavendish described in his "Experiments on Air" in the *Philosophical Transactions* for 1785. By

[1] In a lecture on Argon at the Royal Infirmary in 1895 Lord Rayleigh mentions that he derived this suggestion from Professor Dewar. On the other hand, a letter from Ramsay to Lord Rayleigh (28th November, 1898), reminds the latter that he had suggested Cavendish "at an early date before 1894—certainly before our conversation at which I asked your permission to look into atmospheric nitrogen." He also possessed a copy of Cavendish's paper with a marginal note, "Look into this," written probably about 1896. The point is not of great importance as to who suggested Cavendish; that Lord Rayleigh practically attacked the question is the essential fact.

passing electric sparks through a mixture of "dephlo gisticated air" (oxygen) and common air in contac with a solution of caustic potash Cavendish proved tha the greater part of the "phlogisticated air" (nitrogen was identical with the constituent of nitrates. Th residue, which was too small to be submitted to furthe treatment, was "certainly not more than $\frac{1}{120}$ of the bul of the phlogisticated air let up into the tube; so that i there is any part of the phlogisticated air of our atmo sphere which differs from the rest and cannot be reduce to nitrous acid, we may safely conclude that it is no more than $\frac{1}{120}$th part of the whole."

In the earliest attempts to isolate the suspected ga by the method of Cavendish. a Rhumkorff coil actuate by five Grove's cells was used. This was later replace by an alternate current discharge by which an electri flame is produced, as already shown by Mr. Crookes and the alkaline liquid for absorption was used in th form of a fountain maintained continuously within th globular vessel containing the mixed gases.[1]

Lord Rayleigh having already, in 1892, taken th chemical world into his confidence, it was inevitabl that this essentially chemical problem should attrac the attention of chemists, but it does not appear tha anyone except Professor Ramsay had attempted t attack the question experimentally.

Ramsay's account of what followed was related i 1898 in a lecture given to the Pharmaceutical Societ

[1] *Trans. Chem. Soc.* 1897, p. 184.

on the "Gases present in the Atmosphere," but the progress of his work can be traced by the aid of passages in letters to Lord Rayleigh and to his wife, which have been preserved. Thus he wrote to the latter on 23rd April, 1894:

"By the way curiously I am at work on nitrogen, but not from the commercial point of view, or rather Williams is. Nitrogen of air is heavier than nitrogen from ammonia in the ratio of 251 to 250. That would correspond with the addition of some light gas to the heavy one, or of some heavy gas to the light one. If the light gas were hydrogen, it would need 7 parts in 2000 to make it so much lighter. Now no one has ever taken all the nitrogen out of the air, or rather, after all oxygen has been removed from air, no one has combined all the nitrogen. It is quite possible that there is some inert gas in nitrogen which has escaped notice. So Williams is at it now combining the nitrogen of the air with magnesium, and seeing if there is anything over,—anything not nitrogen. We may discover a new element."

After several previous letters to Lord Rayleigh he wrote as follows on 24th May, 1894:

"I intended to ask you to-day, what is probably quite unnecessary, not to say anything about the gas which I think I have got. It may turn out a mare's nest and it would be well that no one should know of its existence. Another thing occurs to me. I have got a large amount of nitride of magnesium, which when treated with water gives ammonia. I can easily get the nitrogen out of this ammonia, and I shall be glad to give you it, if it can be conveyed to you by any way; or what might perhaps be better, I could give you the ammonia as chloride of ammonium and you could liberate the ammonia and pass it, mixed with oxygen, over red-hot copper. I find on making a

rough calculation that on adding my 60 c.c. of gas of sp. gr. 16 to the nitrogen from which it was obtained it would amount to 3 p.c. of the total, and that such a mixture of N=4 with X=16 would give a gas of the density you find. This is so far encouraging, but I must try to further purify the gas. I think that it still contains some nitrogen, and moreover it will be none the worse of another treatment with hot magnesium.

Has it occurred to you that there is room for gaseous elements at the end of the first column of the periodic table? Thus,

Li	Be	B	C	N	O	F	.	.	.
	,,		,,		,,	Cl			
	,,		,,		,,	Mn	Fe	Co	Ni
	,,		,,		,,	Br			
	,,		,,		,,	?	Pd	Ru	Rh
					etc.				

Such elements should have the density 20 or thereabouts, and 0·8 p.c. (=$\frac{1}{120}$th about) of the nitrogen of the air would so raise the density of nitrogen that it would stand to pure nitrogen in the ratio 230 : 231."

Later on, 4th August, ~~1914~~ 1894, the letter is headed ? *Private*:

"I have isolated the gas. Its density is 19·075 and it is not absorbed by magnesium. The last passage of the gas mixed with nitrogen over red-hot magnesium eight or ten times yielded only 3 milligrams of ammonium chloride from the magnesium nitride formed. I think that there is some 1 p.c. in the nitrogen of the air. . . . The nitrogen prepared from magnesium nitride is chemical nitrogen, *i.e.* it has a density 1/230 below that from air (your experiments). The value of the chemical N_2 is identical with yours. I have been watching the density of X creep up as absorption proceeds; so you see this is no chance determination with a possible source of error."

It is perhaps not surprising that, during several months following the announcement of the new gas, the feeling generally prevalent in this country was one of curiosity mingled with incredulity. This, however, cannot be considered to justify such remarks as those of the President of the Chemical Society at a meeting of the Society on 6th December :

"He ventured to say that Lord Rayleigh and Professor Ramsay now could not hope to keep so remarkable a discovery to themselves much longer. After having been told so much chemists could not be expected to remain quiet under the imputation that they had been eyeless during a whole century, and they would undoubtedly enquire into the matter. Although no one would seek to take the discovery out of the hands of those who had announced it, chemists unquestionably had the right, not only to exercise entire freedom of judgment, but also to critically examine the statements which had been made."

It may be safely asserted that an exhibition of such impatience did not represent the feeling of the scientific world in general. The discovery was accepted almost immediately on the other side of the Atlantic, and the Hodgkin Prize given by the Smithsonian Institution at Washington was awarded to the authors before the end of the year.

In the meantime both Rayleigh and Ramsay were hard at work on the numerous problems arising out of the discovery and especially the remarkable properties of the new gas. Lord Rayleigh had also collected a quantity of the gas from the Bath springs, and already, in October, they were discussing the date at which the

Some remarks about the spectrum of the gas follow, and on the 7th August, in reply to Lord Rayleigh, he wrote again as follows :

"To take the last part of your letter first, I think that joint publication would be the best course, and I am much obliged to you for suggesting it, for I feel that a lucky chance has made me able to get *Q* in quantity (there are two other *X*s, so let us call it *Q* or Quid ?). . . .

I have written out my results in a provisional way as far as they go, verified all my calculations, which were only approximate ones, done in the press of work in the laboratory. It may interest you to have a synopsis which will be a sort of record, and put you at home in all I have done."

The rest of the letter, occupying two sheets, contains an account of his experiments and their results. It winds up as follows :

"The gas *Q* is now filled into a critical point tube and to-day I shall see if I can liquefy it. I shall also try sparking it with chlorine and also its action on potassium. That is all I can get through. I shall tell you on Wednesday or Thursday what the results are. Until Oxford therefore."

The results of the two methods of dealing with atmospheric nitrogen, namely sparking with excess of oxygen in the presence of caustic potash as practised by Lord Rayleigh, and contact with hot magnesium in Ramsay's circulating apparatus, were embodied into a joint paper which was communicated to the British Association meeting in August at Oxford. A little later the question arose as to the identity of the gases obtained by the two methods, and this had to be settled.

paper could be read to the Royal Society. No time was being lost.

On the 14th November Ramsay wrote to his wife:

"To-day I tried platinum black on the gas, but no result as usual. Yesterday sodium dioxide, again fruitlessly. To-morrow Lord Rayleigh is coming to see me in the morning and I am going to show him the circulation. I also tried to liquefy the gas to-day; but the barometer is very low and it is difficult to make liquid nitrous oxide. . . . However, there was no sign of liquefaction."

On the 16th November:

"I had Lord Rayleigh with me from 11 to 3 yesterday and to lunch. He was much interested, and saw that my plan beats his hollow. I showed him an absorption going on. To-morrow I am going to show it to my class. I believe there is to be a crowd. That is not publishing, and I think that one's students deserve the first of anything."

On the 17th November:

"The gas is lying quiet just now. I am recirculating my whole stock and working up a new lot. To-day I made it at the lecture, about 70 c.cs., say a small wine-glassful. That too has joined the common stock. Matthews has stayed all afternoon looking after it. By Monday it will be pure. And then there is a lot to do with it."

The letters which passed between the two experimenters, often more frequently than once a week, show how anxiously and assiduously they were following up the investigation. The spectra of many samples of the gas were also being examined by Mr. Crookes and Professor Schuster, and the behaviour of the gas at low

temperatures was being investigated by Professor C. Olszewski of Cracow, to whom a supply of the gas had been sent. Towards the end of November the preparation of M.S. began, and by this time it appears that the name argon had been adopted, in reference to the chemical inactivity of the new element.

The story was communicated to the Royal Society on 31st January, 1895, and in anticipation of the large attendance of Fellows and visitors a special meeting was arranged in the theatre of the London University in Burlington Gardens. The President, Lord Kelvin, was in the chair, and no one who was present on the occasion will be likely to forget the excitement with which the large audience received from Lord Rayleigh and Professor Ramsay the details of their joint work and an account of the strange properties of the new gas. As everyone now knows, argon is a gas having a density represented by 20 [1] when that of oxygen is 16, hydrogen being the unit. It refuses to enter into combination or to exhibit any chemical change, when heated to the highest temperatures in contact with the most active elements such as sodium, phosphorus, oxygen, or fluorine and therefore differs from every previously known substance. It liquefies under pressure and cold, yielding a colourless liquid which boils at about $-187°$ C. and solidifies to a crystalline mass resembling ice. From the velocity of sound in the gas it is inferred that the molecules of argon, like those of mercury, consist of one

[1] Strictly 19·94.

atom, and its molecular weight is therefore the same as its atomic weight, namely $19{\cdot}94 \times 2$ or $39{\cdot}88$. Accordingly the symbol A or A_1 is given to the element.

The chemical inactivity of argon was the feature of the element which attracted most attention, and naturally great efforts were repeatedly made to get evidence of the formation of a compound by the gas. The announcement by Berthelot of the production of a peculiar viscous compound by exposing benzene vapour and argon to the action of a silent electrical discharge turned out to be a mistake, and there was no reason to suppose that the small quantity of argon absorbed was held in any way except mechanically. Ramsay held the view that "if argon forms a compound it must be with some rare element. It would have been discovered years ago if it had formed one with any of the commoner elements." On the day following the meeting at the Royal Society he received from Mr. H. A. Miers (afterwards Sir Henry), Keeper of the Mineral Department of the British Museum, a letter drawing his attention to the work of Hillebrand (*American Journal of Science* (1890), xi. 384), who reported the frequent presence of what he supposed to be nitrogen in the natural uranates. Both Miers and Ramsay believed that the mineral clèveite, one of the uranates, would be found to contain a compound of argon. On the 17th March, 1895, in a letter to Mr. Buchanan, Ramsay refers to the gas from clêveite as follows:

"Crookes thinks its spectrum is new, and I don't see from the method of treatment how it can be anything old, except argon,

and that it certainly is not. We are making more of it and in a few days I hope we shall have collected enough to do a density. I suppose it is the sought for krypton, an element which should accompany argon. . . . We have settled the question of argon in the animal economy: there is absolutely no trace of argon in peas or in mice. And I have done a good deal as regards density, specific heat and expansion, a paper on which I shall send in to the R.S. for next Thursday."

The presentation of the paper referred to had to be postponed, for within the week the new gas had been identified.

The surprise and delight of Ramsay may be conceived when he found that the gas which he obtained from this mineral contained not only argon, but a gas which from its highly characteristic spectrum was recognised as the hypothetical solar element to which the name *helium* had been given by Lockyer many years before.

On 24th March he wrote as follows to his wife:

"Let's take the biggest piece of news first. I bottled the new gas in a vacuum tube, and arranged so that I could see its spectrum and that of argon in the same spectroscope at the same time. There is argon in the gas; but there was a magnificent yellow line, brilliantly bright, not coincident with but very close to the sodium yellow line. I was puzzled, but began to smell a rat. I told Crookes, and on Saturday morning when Harley, Shields and I were looking at the spectrum in the dark room a telegram came from Crookes. He had sent a copy here[1] and I enclose that copy. You may wonder what it means. Helium is the name given to a line in the solar spectrum, known to belong to an element, but that element has hitherto been unknown on

[1] 12 Arundel Gardens, their home.

the earth. Krypton was what I called the gas I gave Crookes, knowing the spectrum to point to something new. 587·49 is the wave-length of the brilliant line. It is quite overwhelming and beats argon. I telegraphed to Berthelot at once yesterday—'Gas obtenu par moi clèvite melange argon helium. Crookes identifie spectre. Faites communication Academie lundi—Ramsay.' . . . I have written Lord Rayleigh and I'll send a note to the R.S. to-morrow, but it will be merely a claim for priority, for there will be no meeting for a month."

On the 27th March the Annual Meeting of the Chemical Society, only two months after the great meeting of the Royal Society, provided a fitting opportunity for communicating this remarkable discovery to English chemists. The Faraday medal was first presented to Lord Rayleigh and the usual course of proceedings was then interrupted to allow Ramsay to make his communication, which can only be described as startling in its effect on the minds of all present. The *Transactions of the Society* contain the following record of the words spoken by Ramsay on this occasion :

"In seeking a clue to compounds of argon I was led to repeat experiments of Hillebrand on clèveite, which, as is well known, when boiled with weak sulphuric acid, gives off a gas hitherto supposed to be nitrogen. This gas proved to be almost free from nitrogen; its spectrum in a Plücker tube showed all the prominent argon lines, and in addition a brilliant line close to, but not coinciding with, the D lines of sodium. There are, moreover, a number of other lines, of which one in the green blue is especially prominent. Atmospheric argon shows, besides, three lines in the violet which are not to be seen, or if present, are excessively feeble in the spectrum of the gas from clèveite.

This suggests that atmospheric argon contains, besides argon, some other gas which has as yet not been separated and which may possibly account for the anomalous position of argon in its numerical relations with other elements.

Not having a spectroscope with which accurate measurements could be made, I sent a tube of the gas to Mr. Crookes, who has identified the yellow line with that of the solar element to which the name 'helium' has been given. He has kindly undertaken to make an exhaustive study of its spectrum.

I have obtained a considerable quantity of this mixture and hope soon to be able to report concerning its properties. A determination of its density promises to be of great interest."

It is scarcely necessary to remark that at that time no one expected to make a close acquaintance with helium as a terrestrial element. The line D_3 characteristic of the element supposed by Lockyer to exist in the sun had been measured many years previously by Ångström and by Cornu and their estimates were now confirmed by the work of Crookes, who gave the wave-length as 587·45.

The mineral clèveite is a variety of uraninite, and minerals containing the element uranium were found very generally to yield more or less helium together with hydrogen, nitrogen and other gases. Helium was found to be like argon, chemically inert. Its density is a little less than twice that of hydrogen, namely 1·99 and it is composed of monatomic molecules, like those of argon. Its molecular weight is therefore approximately 4 and the symbol is He. It may be added here that all attempts to liquefy helium remained for many

years fruitless and that the liquefaction was accomplished in 1908 by Professor Kamerlingh-Onnes of Leiden. The boiling point of the liquid is the lowest known, as it is approximately 4·5° absolute or 268° to 269° below zero Centigrade.

Immediately after the meeting of the Chemical Society in London Ramsay and his wife went to Paris in fulfilment of an engagement to lecture on argon to the Société Chimique de Paris. Before leaving home he received through M. le Chatelier an urgent request that he would give a demonstration on the same subject to the 500 students of the École Polytechnique. This he consented to do, and in a letter to his children, dated, Paris 31st March, 1895, he gave them an account of the proceedings on both occasions. Needless to say, the lectures were received with enthusiastic applause.

This period, so full of interest and excitement, must have been very exhausting to Ramsay, for it must not be forgotten that the teaching at University College made considerable demands on his time and energy. At the end of the session he wisely sought a holiday under conditions which would make him secure of uninterrupted relief, and in company with his colleague, Professor W. P. Ker, he started in August for Iceland. Some account of this excursion will be found later on. Some bottles of gas were collected at the hot springs near Reykjavik, but they appear to have contained no helium but only a notable quantity of argon. (Kellas and Ramsay, *Proc. Roy. Soc.*, Nov. 1895.)

The following spring Ramsay visited Cauterets in the Pyrénées accompanied by Dr. Morris Travers. They started from the Thames and went by sea to Bordeaux and on by train to Pau. Thence they travelled to Pierrefitte, visiting Lourdes on the way, and reached Cauterets in a snowstorm. An interesting letter to his wife, giving an account of the visit to the springs, is dated 2nd April, 1896. The *Proceedings of the Royal Society*, 4th Feb., 1897, contain an account of the examination of the gas from Cauterets, which was found to contain both argon and helium.

A difficulty which presented itself in connection with these new elements was the impossibility of finding for them a suitable place in the periodic scheme of Mendeléeff, which had already been accepted by the chemical world for the classification of all the previously known elements. This difficulty was discussed in the latter part of the paper by Ramsay, Collie and Travers on the sources and properties of helium, published in the *Transactions of the Chemical Society* for June 1895. Here it was pointed out that "if argon possesses the atomic weight 40, there is no place for it in the periodic table of the elements." At the anniversary meeting of the Royal Society on November 30th in that year, the Davy Medal was awarded to Ramsay on grounds which are set forth in the following passage in the President's Address. After referring to his earlier work, chiefly in connection with problems in physical chemistry, it proceeds :

"But the researches on which the award of the Davy Medal to Professor Ramsay is chiefly founded are, firstly, those which he has carried on, in conjunction with Lord Rayleigh, in the investigation of the properties of argon, and in the discovery of improved and rapid methods of getting it from the atmosphere; and, secondly, the discovery in certain rare minerals of a new elementary gas which appears to be identical with the hitherto hypothetical solar element, to which Mr. Lockyer many years ago gave the name of 'helium.' . . .

The conferring of the Davy Medal on Professor Ramsay is a crowning act of recognition of his work on argon and helium which has already been recognised as worthy of honour by scientific societies in other countries. For his discoveries on these gases he has already been awarded the Foreign Membership of the Société Philosophique de Genève and of the Leyden Philosophical Society. He has had the Barnard Medal of the Columbia College awarded to him by the American Academy of Sciences, and within the last few weeks he has been elected a Foreign Correspondent of the French Académie des Sciences."

The novel characters of the gases, helium and argon, led to great activity in the scientific world, and for a time the journals were filled with speculations as to their origin, their atomic constitution, their recognition in the earth's atmosphere and in the heavenly bodies, and their position in the scheme of known elements. The excitement extended beyond scientific circles, and all sorts of amateur physicists plunged into extravagant hypotheses as to the functions of argon in nature. Even young students were infected with the epidemic, and the answers to examination questions showed that oxygen as a constituent of our air was almost forgotten in the

anxiety on the part of the candidate to show that he o
she knew all about argon.

The actual state of knowledge concerning the nev gases in 1897 will best be described in Ramsay's owı words, and fortunately an excellent summary is giveı at the end of a paper which he communicated to th *Annales de Chimie et de Physique* and which appeared in April 1898. The following is a slightly abbreviated translation of this summary :

"Without attempting to mention the numerous theories and hypotheses which have been published with reference to argoı and helium, we will confine ourselves to positive facts.

The densities of helium and argon are respectively 1·98 and 19·94. The relation between the specific heats at constan volume and constant pressure for each gas is 1·65. This relatioı can only be consistent with the simplest molecular structure The molecules must be incapable of motion of any kind excep that in virtue of which they traverse space. If there is any other kind of motion, it can only be exceedingly small. Th imaginary atoms of Boscovich could alone strictly comply witl this condition, and since these gases give well-defined spectra it follows that they are not entirely without internal movement All that can be stated therefore is that the vibration whicl produces the spectrum cannot be considerable enough to hav an appreciable influence on the ratio of their specific heats.

We may recall the fact that mercury, an element which fo other reasons is regarded as mono-atomic, exhibits the same relation. It seems that the conclusion is inevitable that th molecules of helium and argon are each formed of one atom Hence it follows that the atomic weight is double the density or 3·96 for helium and 39·88 for argon.

If these gases, however, are not homogeneous, if they consist

of mixtures of mono-atomic elements, these atomic weights would be merely the mean atomic weights of the elements contained in such mixtures taken in the proportions in which they are present. We must ask therefore what evidence there is that they are mixtures. Considering helium first, MM. Runge and Paschen, Mr. Lockyer and others have maintained that spectral analysis shows helium to be in reality a mixture of two elements. It is sufficient to remind the two German savants that they have expressed the view that the evidence of complexity of helium applies also to the case of oxygen. No one hitherto has suspected oxygen of being a mixture. Our repeated efforts to effect a separation of helium into two elements, by means of diffusion, have only succeeded in showing that the helium from minerals may contain a small quantity of argon. If there were two elements they must have the same density. As to the hypothesis of Mr. Lockyer, who bases his idea on the fact that the stars do not exhibit all the lines of helium, it must not be forgotten that greater or less pressure, and temperature more or less elevated, produce considerable differences in the spectrum of helium in the relative intensity of the lines and even in their existence. Our knowledge of the conditions prevailing in the stars is so incomplete that it may well happen that certain lines are missing and we can draw no conclusion therefrom.

I cannot answer for the homogeneity of argon with the same assurance. Diffusion experiments gave two portions of gas, the one having the density 19·93, the other less diffusible 20·01. If, however, there is any foreign gas present, it must be in very minute quantity, and would have no considerable effect on the atomic weight.

The mono-atomicity of helium is connected with its other physical properties. Having an atomic weight nearly four times that of hydrogen, it ought to have a higher boiling point. However, Professor Olszewski has been unable to liquefy it at a temperature much lower than that at which hydrogen becomes

liquid. This leads to the supposition that its structure must be simpler than that of hydrogen. We are accustomed to believe that the polymerisation of a substance raises its boiling point, and accordingly since hydrogen gas is the polymer of the unknown atomic hydrogen, its liquefaction is possible.

In support of the hypothesis of the mono-atomicity of helium may also be cited its extraordinary conductivity for electricity, its feeble refractivity for light and its unexpected rapidity of diffusion. As it possesses exceptional properties, we are led to conclude that its molecular constitution is different from that of other gases.

With regard to the position of argon in the periodic scheme it is sufficient to indicate that if it possesses an atomic weight higher than that of the element which succeeds it in the table, namely potassium, it is not alone in this peculiarity, for the atomic weight of tellurium is undoubtedly above that of iodine, its successor in the table.

Admitting then that the atomic weight of helium is about 4, and that the atomic weight of argon is about 40, the difference between these two figures is 36. Now this is just the difference observable among the members of the following series :

Fluorine	19		Oxygen	16		Nitrogen	14	
		16·5			16			17
Chlorine	35·5		Sulphur	32		Phosphorus	31	
		19·5			20·3			20·4
Manganese	55		Chromium	52·3		Vanadium	51·4	

Carbon	12		Boron	11		Glucinum	9·1	
		16·3			16			15·2
Silicon	28·3		Aluminium	27		Magnesium	24·3	
		19·8			17·1			15·8
Titanium	48·1		Scandium	44·1		Calcium	40·1	

Lithium	7		Helium	4	
		16			16
Sodium	23		?	20	
		16·1			20
Potassium	39·1		Argon	40	

The differences between the extremes are as follows:

Manganese—Fluorine	36
Chromium—Oxygen	36·3
Vanadium—Nitrogen	37·4
Titanium—Carbon	36·1
Scandium—Boron	33·1
Calcium—Glucinum	31
Potassium—Lithium	32·1
Argon—Helium	36

These differences are not very far from 36.

I believe therefore that an element hitherto unknown should find a place between helium and argon. We have looked for this element in vain. However, we have not given up the search, and if we succeed the discovery would throw much light on the nature of helium and argon."

In September 1897 the meeting of the British Association took place at Toronto in Canada, and Ramsay was President of the Chemical Section. The customary address was occupied chiefly with an exposition of the relations of helium and argon very nearly on the lines of the summary just given.

With these considerations as a guide the discovery of an elementary gas, having a density 10 and atomic weight 20, was foretold. This prophecy, however, was not realised till a year later, when Ramsay and Travers announced in June 1898 the discovery of a new gas in the least volatile portion of a large quantity of liquid air. This gas they named *krypton* (hidden). A fortnight later they discovered another gas called *neon* (new), which was found to possess the density required for the

element predicted for the position between helium and argon. A gas named metargon, announced at the same time, proved afterwards to be a mixture containing carbonic oxide. By allowing a large quantity of liquid air to evaporate quietly, and removing oxygen and nitrogen from the residue, a mixture of argon and krypton was obtained, in which was detected yet another gas in small quantity, to which the name *xenon* (the stranger) was given. All these gases agree with argon in chemical inactivity and in consisting of monatomic molecules. Their densities, boiling points, critical temperatures and pressures, refractivities and spectra have been examined and recorded. and the "Companions of Argon" form a complete series running parallel with the halogen elements on the one side and with the alkali metals on the other, as shown below :

Hydrogen 1	Helium 4	Lithium 7	Glucinum 9
Fluorine 19	Neon 20	Sodium 23	Magnesium 24
Chlorine 35·5	Argon 40	Potassium 39	Calcium 40
Bromine 80	Krypton 82	Rubidium 85	Strontium 87
Iodine 127	Xenon 128	Caesium 133	Barium 137

Here the atomic weights are given in round numbers, but when the most accurate determinations of the atomic weight of argon are compared with those of potassium, the figure for the former element is still too great Taking the atomic weights given in the most

recent *Table of the International Committee* (1916), namely A=39·9, K=39·1, the value for argon is too high. It looks therefore as though this was an anomaly similar to that which has for so many years been a subject of repeated investigation, namely the relation of tellurium (Te=127·5) to iodine (I=126·92).

As Ramsay remarks at the end of one of his papers (*Proc. Roy. Soc.* 67, 333), "the conundrum of the periodic table has yet to be solved."

Of the companions of argon, neon, krypton and xenon are found with it among the constituents of our atmosphere. Helium, however, the lightest of them all, was not at first detected in the air, notwithstanding repeated experiments made by Lord Rayleigh and by Ramsay with this object. It is, however, curious that helium is found in connection with certain sources of hot mineral waters, though not in all. Thus the water of the geysers in Iceland contain not a trace, neither do the waters of Harrogate and Strathpeffer, while the springs at Wildbad, in the Black Forest, are said to contain small quantities, and it has also been found in the waters of Bath and Cauterets (Basses Pyrénées).

Helium was recognised in the air much later by Baly and others (*Nature*, October 1898).

The late Dr. Johnstone Stoney, in discussing the atmospheres of planets and satellites (*Trans. Roy. Dublin Society*, 1897), expressed the view that the composition of the atmosphere composed of a mixture of gases depends on the velocity of translation of the

molecules and the mass of the central body. The composition of the earth's atmosphere, the absence of atmosphere around the moon and the composition of the solar atmosphere, which contains hydrogen and helium mixed with heavier gases, are thus explained, and it appears that a gas of lower density than ammonia would sooner or later disappear from the earth. Hence any helium in our atmosphere would escape sooner or later.

The annual meeting of the Chemical Society was this (1897) year marked by two events, both of which testify to the position Ramsay occupied in the esteem of the chemists of his own country. The presentation of the Longstaff Medal, "for the discovery of helium and for his share in the investigation of argon," represented only another unit in the long series of prizes and distinctions which had fallen to his lot, and being available only once in three years, this was the first opportunity for the award of the medal by the Council. This year, however, was the unprecedented occasion of a division in the Chemical Society in regard to the nomination of President. In accordance with custom the new president was nominated by the Council for election at the annual meeting. A considerable number of the Fellows, however, being desirous of seeing Ramsay in the chair, proposed him formally in opposition to the official nominee. That this was done without his knowledge is shown by a passage in a letter to his friend Fyfe, dated the 21st March, ten days before the anniversary,

which runs as follows: "Last Thursday I wasn't at the meeting, for Fitzgerald was arriving that evening, and next morning I heard to my horror and surprise that 116 of the Fellows had nominated me." The matter being pushed to a conclusion, the scrutators reported, after a recount, 152 votes in his favour against 166 for the Council's nominee. But happily the ferment settled down, and ten years later Ramsay became President of the Chemical Society.

The history of these remarkable discoveries would not be complete without some reference to the attacks made from time to time on Ramsay, in which it was alleged that he had endeavoured to appropriate a larger share of credit in connection with the work than his due. The correspondence which has been preserved shows that no feeling of this kind existed on the part of Lord Rayleigh. Very wisely neither of the co-discoverers replied to these attacks. Twenty years have passed since that time, and Ramsay's reputation not only for scientific insight, and experimental skill, but for manly straightforwardness and honesty of purpose combined with enthusiasm, has long since been established beyond the reach of jealousy and detraction.

At the end of the year 1898 Ramsay was in Berlin, and on 19th December he gave a lecture on the gases to the German Chemical Society, and a report was printed in the *Berichte* (p. 3111). The following day, at the request of the Empress, he gave an account of their chief properties to the court, and the Emperor and

Empress accompanied by Sir Frank Lascelles, British Ambassador, came to the Chemical Institute. On the 21st he lectured in German to a very large audience at the Urania, the Berlin popular institute of sciences.

APPENDIX I TO CHAPTER V

It has already been mentioned that Ramsay was President of the Chemical Section of the British Association meeting at Toronto, and a short summary of his address has been given. The story of the journey with his family to Canada and back cannot be told better than in his own words in a letter, dated 10th October, to Mr. Fyfe on his return home.

"When we started on the *Parisian* I think I knew 70 of our fellow-passengers, not including many wives; so there was no lack of company. We took our meals next old Turner of Edinburgh,[1] who was a very pleasant and talkative neighbour. He keeps his eyes on people's skulls. By the way Mag had the broadest on board; but Elska and Willie had the more dolichocephalic than even I. We had the usual carryings on—concerts, lectures—one excellent evening of tales from Selous concerning his chase of elephants and lions, and also concerning him in the rôle of the hunted; the last was exceedingly dramatic. . . . I stood his sponsor on admitting him into the Red Lion Club later on at Toronto. I pled two excuses on his behalf; first that he had been known to run away from a lion; second that he had once missed a lion; and promised on his behalf that while in

[1] The late Sir William Turner, Professor of Anatomy, afterwards Principal and Vice-Chancellor of the University. He died in 1916 at an advanced age.

America he would never kill a lion. Donald MacAlister, who was the "Lion-King," bestowed on him the degree of L.L.D.—'Leo Leonum Destructor.' Sir George [1] Robertson of Chitral was also one of our fellow-passengers, and he and Selous capped one another's stories and made us much joy. It was not a 'sick transit' and the 'gloria mundi' was unabated. We went straight into Montreal by the *Parisian* and took up our quarters with Mr. Russell Baldwin, who was a most exemplary host. The section pursued its usual course, and we had a good attendance of U.S. chemists, among others a number of my old friends. Remsen was there, also Clarke from Washington, and a lot of others whom you never heard of. The usual round of garden parties and receptions was given, and Lord and Lady Aberdeen graced the show. At a final dinner given to us by the municipality, he being in the chair, he shouted out 'Is the Bishop of Ontario present?' No reply. 'Is the Reverend Augustus Thomson present?' No reply. 'Then thank God for these and all His mercies.' [2]

... From Toronto we went straight west on the Canadian Pacific Ry. We took the lake route and spent ten days on Huron and Superior. Then by train to Winnipeg, considerably grown but not so much altered as I expected after 13 years, and on to Glacier, crossing the Rockies and the Selkirks. One fine morning, at 6 o'clock, on approaching the Rockies, Elska and I were on the end platform of our carriage, which was the end of the train. We were jogging along at the customary 20 miles an hour. Suddenly a band of Indians dressed in coloured blankets and with eagles' feathers on their heads galloped out from behind a small wood and drew up, reining in their horses on their haunches, quite close to us. We waved to them and they to us, and we steamed slowly ahead. It was a romantic sight and

[1] This must be a mistake for Brig.-Gen. William Robert Robertson.

[2] This is a sort of personal parody of the query by C. V. L. in Charles Lamb's "Grace before meat."

reminded us of the old Fenimore Cooper days. Most of these people look like very decayed gentlemen, grave and sedate, but very seedy. The Rockies are rocky and bare, the Selkirks like the Alps;—all covered with snow and with pine trees on the lower slopes.

Then we came back. Most of our friends went on to Vancouver and Victoria; but we wanted to spend as long a time as possible with Pat Buchanan. So we turned at Medicine Hat—the oddest of a lot of odd names along this route—and took a narrow gauge line south to Montana. At Great Falls, on the Missouri, we found Pat, and were introduced to his numerous acquaintances there. It is a pretty town and perfectly civilised. By the way, in all American towns the electric car is the chief feature. There are overhead wires and cars like our tram cars, run at a prodigious rate, careless of life apparently, yet there are very few accidents. I suppose the fittest, *i.e.* those who don't get killed, survive. They are delightful as a form of motion and almost rival the bicycle. That creature, too, has penetrated everywhere, and is used even over the prairie. We drove out to Pat's ranche, and stayed there for 11 days. It is a fine place. He and his partner must possess at least 20 miles square of territory,—as much say as Stirlingshire. It is not all theirs, but they hold all the water, and the rest of the land is useless to anyone else. They lead an Arcadian life, have a comfortable house and many helps,—men, horses and cows and innumerable sheep. They are doing first rate now that the wool is looking up.

To cut a long story short, we came back viâ Niagara and stayed three days at Springfield, Mass., with Southworth, Remsen's brother-in-law, very pleasantly; caught the steamer at Quebec, and after a good passage got home last Monday. It seems as if I had never been away. Such is the perversity of human nature."

APPENDIX II TO CHAPTER V

Apparatus used by Rayleigh and Ramsay for isolating argon on a large scale from the air.

Figure 1—Magnesium Method.

A is the circulator. It consists of a sort of Sprengel's pump (*a*), to which a supply of mercury is admitted from a small reservoir (*b*). This mercury is delivered into a gas-separator (*c*), and the mercury overflows into the reservoir (*d*). When its level rises so that it blocks the tube (*f*) it ascends in pellets or pistons into (*e*), a reservoir which is connected through (*g*) with a water-pump. The mercury falls into (*b*) and again passes down the Sprengel tube (*a*). No attention is therefore required, for the apparatus works quite automatically.

The gas is drawn from the gasholder *B*, and passes through a tube *C*, which is heated to redness by a long flame burner and which contains in one half metallic copper and in the other half copper oxide. This precaution is taken in order to remove any oxygen which may possibly be present (in the atmospheric "nitrogen" used), and also any hydrogen or hydrocarbon. In practice it was never found that the copper became oxidised, or the oxide reduced. The gas next traversed a drying tube *D*, the anterior portion containing ignited soda lime and the posterior portion phosphoric anhydride. From this it passed to a reservoir *D'*, from which it could be transferred, when all absorption had ceased, into the small gasholder. It then passed through *E*, a piece of combustion-tube, drawn out at both ends, filled with magnesium turnings and heated by a long flame burner to redness. Passing through a small bulb, provided with electrodes, it again entered the fall-tube.

After the magnesium tube *E* had done its work, the stopcocks were all closed, and the gas was turned down, so that the burners

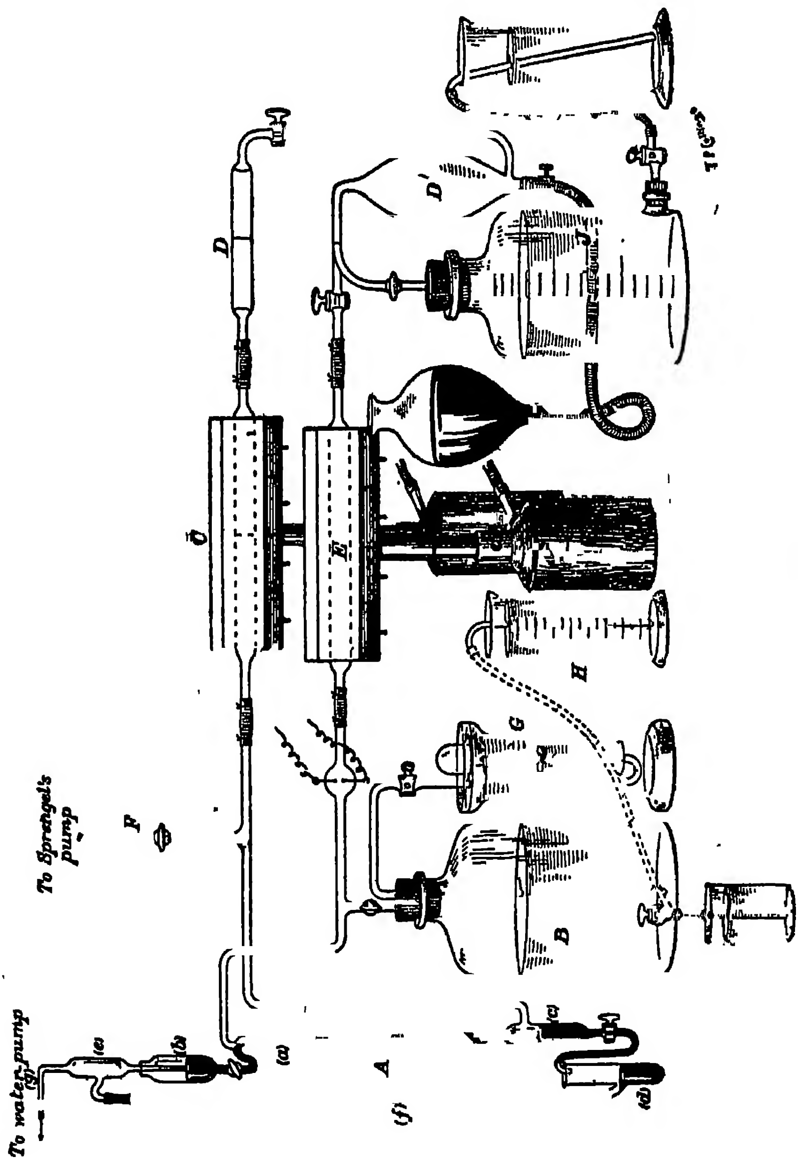

Fig. 1.

might cool. The mixture of argon and nitrogen remaining in the system was pumped out through a Sprengel pump through *F*, collected in a large test-tube and re-introduced into the gas-holder *B* through the side tube *G*, which requires no description. The magnesium tube was then replaced by a fresh one; the system of tubes was exhausted of air; argon and nitrogen were admitted from the gasholder *B*; the copper tube and the magnesium tube were again heated; and the operation was repeated till absorption ceased. It was easy to decide when this point had been reached, by making use of the graduated cylinder *H*, from which water entered the gasholder *B*. It was found advisable to keep all the water employed in these operations, for it became saturated with argon. If gas was withdrawn from the gasholder, its place was taken by this saturated water. By means of magnesium about 7 litres of nitrogen can be absorbed in an hour. The changing of the tubes of magnesium, however, takes some time; consequently the largest amount absorbed in one day was nearly 30 litres.

From the result of a special quantitative experiment it may be concluded, with probability, that argon forms approximately 1 per cent. of the atmospheric nitrogen.

FIGURE 2—OXYGEN METHOD.

The vessel *A* is a large globe of about 6 litres capacity and stands in an inclined position. It is about half-filled with a solution of caustic soda. The neck is fitted with a rubber stopper *B*, provided with four perforations. Two of these are fitted with tubes *C*, *D*, suitable for the supply or withdrawal of gas or liquid. The other two allow the passage of the stout glass tubes *E*, *F*, which contain the electrodes. For greater security against leakage the interior of these tubes is charged with water held in place by small corks, and the outer ends are cemented up. The electrodes are formed of stout iron wires, terminated by thick platinums *G*, *H*, triply folded together and welded at

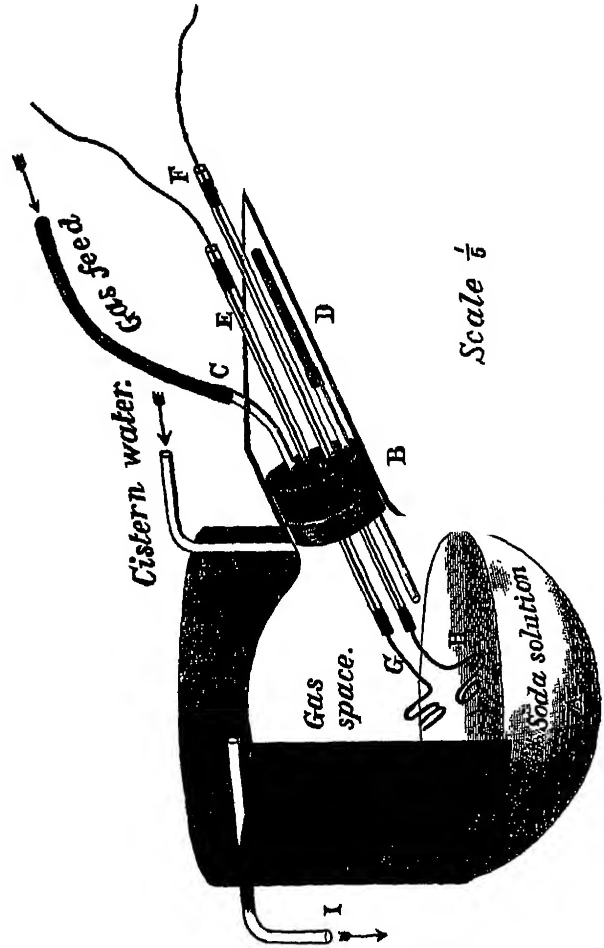
Gas feed
Cistern water.
F
E
C
D
B
Scale $\frac{1}{5}$
Gas space.
G
H
Soda solution
I

FIG. 2.

the ends. The upper part of the flask is cooled by water, which is enclosed by a lead wall partially shown at *I*. For greater security the india-rubber cork is also drowned in water, held in place with the aid of sheet-lead. The lower part of the globe is occupied by about 3 litres of a 5 per cent. solution of caustic soda, the solution rising to within about half-an-inch of the platinum terminals. In a successful experiment 9250 c.c. of air were used and 10,820 c.c. of oxygen were consumed, the proportion of oxygen being to nitrogen as 1·75 to 1·0, that is, more than sufficient to convert the nitrogen into nitrous acid, in which form it is absorbed. The argon ultimately left after absorption of the excess of oxygen amounted to 75 c.c., or a little more than 1 per cent. of the atmospheric "nitrogen" used. (*Phil. Trans.* vol. 186, part I A, p. 212 to p. 219.)

CHAPTER VI

WORK ON RADIUM

In 1902 radium salts were isolated by Madame Curie, and naturally the physical and chemical properties of these remarkable substances attracted a large number of investigators. Ramsay desired to examine the spectrum of the "emanation" which is evolved from radium, and with the co-operation of Dr. Frederick Soddy, who had come to work in his laboratory in the autumn of 1903, experiments were begun with this object. Ramsay was a skilled manipulator of small quantities of gas, having determined the physical properties of xenon with less than 4 cubic centimetres, but in the case of the emanation where it was a matter of cubic *millimetres* special apparatus had to be devised. After some preliminary attempts, vacuum tubes were made out of thermometer tubing, and the emanation being admitted the experimenters were surprised to find helium present. Subsequently the volume of emanation evolved in a given time from a given weight of radium bromide, and the quantity of helium disengaged from a known volume of emanation were approximately measured.

The emanation was recognised as possessing the properties of a true gas obeying Boyle's law like other gases. It had been previously shown by Rutherford and Soddy to be chemically inert like argon. This production of helium from the emanation Ramsay speaks of as the first observed case of "transmutation," for radium and its emanation as well as helium must be counted among the substances known as "elements." This idea developed later into the conviction that radio-active change might be made use of to effect the transmutation of the common elements. This subject will be referred to later.

The important discovery just described gives the clue to the sources of helium in natural spring waters which evidently rise through or from radiferous rocks. As to the homologues of helium, namely argon and the rest, no corresponding source is known. But if analogy may be relied on it seems probable that argon, neon, krypton and xenon are, like helium, products of radio-active change occurring in substances similar in constitution to radium but having much higher atomic weight and a far more unstable constitution. These have long since disappeared from among the known mineral constituents of this earth's crust. Ramsay does not seem to have occupied himself with this point of view, which obviously cannot be put to the test of experiment.[1] Some years later he seems to have thought it possible that neon and

[1] This speculation is discussed in the pages of a little book, *The Elements*, by Sir W. A. Tilden (Harpers).

argon result from partial degradation of the rad emanation (*Trans. Chem. Soc.* 1907, p. 1605).

The search which Ramsay undertook later (*Proc.* *Soc.* 81, p. 178) concerning the existence in the atr phere of possible new members of the inactive serie gases led to a negative result. With the aid of Mr. H Watson, who photographed the spectrum of the lig constituents of the air, and of Professor Richard Moore, who investigated the less volatile portions o less than 120 tons of liquid air, no new constituen the atmosphere could be detected. But Ran pointed out that there are gaps in the periodic t which conceivably might be fitted by elements of inactive series having a higher atomic weight than of xenon. From the known gradation of proper passing from helium to xenon it was certain that missing elements must be gases, and it was alr equally certain that they would form no compounds.

Three gases were known which are as inactive che cally as those of the argon group, but they disinteg during the process of separation. These were the em ations from radium, thorium and actinium. Var attempts to determine the atomic or molecular wei of the emanations of radium and thorium led only an estimate for the emanation of radium as about Ramsay was, however, dissatisfied with the condi of uncertainty in which this interesting problem left in 1908. And soon afterwards he began a se of experiments, with the assistance of Dr. Whytlaw G

on the direct estimation of the density of the radium emanation.

This research must be regarded as one of the most wonderful ever recorded in the annals of experiment. Remembering the exceedingly small volume of the emanation obtainable from a relatively large weight of radium, it is not surprising that other experimenters using methods based on the measurements of the rate of diffusion or of effusion had arrived at widely divergent values for the density of the gas. The majority of the numbers obtained pointed to an atomic weight either 176 or 222, and these are the tabular atomic weights of the two next terms following xenon in the periodic table, thus:

Helium	Neon	Argon	Krypton	Xenon	I	II
4	20	40	83	130	176	222

The problem, then, to be attacked was the determination of the weight of emanation evolved in a given time from a known weight of radium. The volume being already known from the experiments of Rutherford in 1903, those of Debierne in 1909, and confirmed shortly afterwards by Gray and Ramsay. As shown in the paper communicated to the Royal Society in December 1910 (*Proc. Roy. Soc.* **84 A**, p. 536), the total volume of the gas obtainable for weighing scarcely exceeded $\frac{1}{10}$ cubic millimetre, a scarcely visible bubble, and if the atomic weight is assumed to be 222 the weight is less than $\frac{1}{1400}$ milligram. It is evident therefore that in

order to weigh this minute quantity of gas with sufficient exactness a balance turning with a load not greater than $\frac{1}{100000}$ milligram was a necessity. Such a balance has been constructed and described by Dr. B. D. Steele and Mr. Grant, of the University of Melbourne, and they showed that a sensibility of $\frac{1}{250000}$ milligram could be attained. It would be impossible to convey in these pages any clear idea of the operations involved in the construction of the balance, the collection of the gas to be weighed and the manipulation during the process of weighing. Every student of chemistry and physics should read carefully the description of the work set forth in the paper referred to. All that need be added is the result of the five concordant experiments recorded in the paper, and the mean of them, namely

227	226	225	220	218	Mean 223

The density, and hence the atomic weight, of the gas were therefore settled. In view of the character of the emanation, which is a gas belonging to the argon series of inactive elements, Ramsay assigned to it the name *niton*, with the symbol Nt. The concluding words of the memoir express very clearly the importance of the result.

"The research, of which the foregoing is an account, yields a further proof, if such were necessary, of the beautiful theory of the disintegration of the radio-active elements originally advanced by Rutherford and Soddy in 1902. The determination of the density of a gas, even with approximate exactness, has always been regarded as establishing its molecular weight, the accurate

value of which may have been derived from other considerations. In the present case these considerations are the result of the disintegration theory. Determinations by Madame Curie and by Thorpe of the atomic weight of radium show beyond all doubt that it differs little from 226·4. That four atoms of helium separate from one atom of radium is rendered almost certain from the work of Dewar and from experiments by Rutherford and by Ramsay and Soddy. That three atoms of helium are lost by niton on decay has been shown in the preceding pages. It follows that one helium atom must escape when radium changes into its emanation; hence the true atomic weight of the emanation must be 222·4. This number hardly differs from the mean of the atomic weight determinations given in this paper; and the disintegration theory receives a further confirmation."

Ramsay's views as to the utilisation of radio-active change to effect chemical decomposition and even "transmutation" of elements, have already been referred to. His study of the emanation of radium, or niton as he called it, led him to consider this problem seriously and to make experiments, the results of which are recorded in two papers[1] communicated to the Chemical Society in 1907. The first of these commences with the following remarks:

"The emanation from radium is one of the most potent, if not the most potent chemical agent which exists in nature. Of all known substances it is endowed with the greatest content of potential energy; for one cubic centimetre contains, and can evolve, nearly three million times as much heat as an equal volume of a mixture of two volumes of hydrogen with one of

[1] *Transactions* (1907), p. 931, part i.; *Transactions* (1907), p. 1593, part ii. (Cameron and Ramsay).

oxygen. The spontaneous change which it undergoes, moreover, is accompanied by the emission of an immense number of corpuscles, expelled with a velocity approaching that of light in magnitude and which have a remarkable influence on matter."

With the design of applying this immense and concentrated store of energy to the production of chemical change, experiments were first made on the action of radium bromide on water, then on the action of the emanation on water, and on a mixture of oxygen and hydrogen. Giesel was the first to observe the fact of the decomposition of water by radium salts, but Bodländer and later Ramsay and Soddy found that the mixture of evolved gas contains an excess of hydrogen. Ramsay now found that the action is reversible, but that the velocity of decomposition of water by the emanation is greater than that of the recombination of the resulting gases. The rate at which water is decomposed by the emanation presents a problem which was found to be insoluble in the present state of knowledge.

The second paper referred to contains an account of the action of emanation on solutions of copper and lead. The details concerning the apparatus and operations involved are very complicated, and every precaution seems to have been observed against the introduction of impurity and the possibility of error. The conclusions however, are of such fundamental significance that no amount of skill and labour would be wasted in their verification. For these experiments lead to the sug

gestion that the elementary atoms of copper and lead undergo a process of degradation, the former into sodium and lithium, the latter into products not finally identified. Thorium nitrate submitted to the same action continually produces carbon dioxide. At the same time the helium which is evolved when emanation is left alone or in admixture with oxygen and hydrogen gases is replaced by argon when a copper salt is simultaneously present in solution. Other suggestions are made in this important paper, and letters to his friend Worthington give evidence of the fermentation which this interesting subject set up in his mind. Thus, the following passage occurs (21st Nov., 1906):

"I have the first proof that lead nitrate plus emanation gives CO_2. I am, of course, repeating. Other things don't, so far as I have tried them, except thorium nitrate. . . . The order of events appears to be: radium emanation, which is obviously an argon gas, gives, when it disintegrates besides Rutherford's A, B, C, etc., about 7·5 p.c. of its weight of He. $CuSO_4 . Aq$ plus emanation gives Li_2SO_4, and now $Pb(NO_3)_2$ and $Th(NO_3)_4$ give CO_2. I think that the pouring of such thundering amounts of energy as come off the Ra emanation into these atoms (counting these 7·5 p.c. of the Ra emanation as also affected by the energy given off by the odd 92·5 p.c. which disintegrates) brings them down to their lowest members.

Thus Li is the lowest member of the Cu group.
" He " " " A "
" C " " " Pb and Th groups.

Other members may be formed simultaneously. I think that Na is also formed from Cu. I can't tell whether A or Kr are formed from Em^n, or whether Si, Ti, etc., are formed from Pb

or Th. We will see. I have expts. on now to try whether Al, In and Te give B; and whether Bi gives N_2. I think I can detect these."

Again (25th July, 1907) we find:

"I am now trying to see whether the sodium one finds is real, by using a silica bulb. . . . I am pretty sure that Na must be formed, for Na is a much commoner element than Li in nature, and if copper is to be degraded it would more likely go to the stable form of Na rather than to the less common, and therefore probably more unstable form of Li. Also I want to be dead certain that argon is not derived from the atmosphere. . . . The next shot would be to try some heavier metal, say gold, and see if krypton will not be formed from the emanation. Gold, too, should give alkali metals."

In a letter to Dr. Travers (20th May, 1907) Ramsay says:

"I have got lithium from copper for the third time; and Cameron, one of our students, is repeating so as to give a final check. It will be done in a month and a half,—say by the end of June."

The uninitiated will be unable to appreciate the enormous difficulties attending such investigations, the extreme minuteness of the quantities to be dealt with in the endeavour to recognise the products and the practical impossibility of completely excluding impurities derived from the air, the water employed and the surfaces of the glass, silica or metallic vessels necessarily employed. Ramsay himself knew all about this, no one better, and in dealing with the emanation itself when using the

microbalance as already mentioned he was troubled by the condensation of air, and in a letter to Dr. Travers he mentions (27th Nov., 1910) that "*All* water leaves a weighable residue from a drop, and that introduces fresh difficulties in working on a small scale." This residue is doubtless derived from the atmosphere, if the water has been in contact with ordinary air even for an instant.

The position of these interesting speculations is still unsettled. But it may be pointed out that hypothesis has been lavished on the question as to the origin of the known elements. It seems to be generally admitted that they were formed by the condensation, under suitable but probably varying conditions, of one or more primary forms of matter, and that the comparatively stable forms of the condensed material have ranged themselves in groups and series which are summed up in the periodic scheme of Mendeléeff or some modification of it. There seems to be some evidence of the reverse operation proceeding spontaneously in the disintegration of the radio-active substances, and there is surely justification for an attempt to utilise the enormous energy which becomes available in this process in the endeavour to break down the atoms of those common elements which are not appreciably radio-active and which are apparently permanent under conditions now prevailing in this part of the universe. It is true that other experimenters have not confirmed Ramsay's published statements, but in such a field of work it is not surprising

that equally skilled operators should arrive at irreconcilable results. All that we can now hope for is that when peace once more allows the undisturbed pursuit of experimental investigations, this great problem will be resumed and brought to an incontestable issue.

This is not the place to describe with any detail the manufacture or properties of radium and its salts, but the general reader may be reminded that radium is found in uraniferous minerals, of which the most important is pitchblende, the oxide U_3O_8. The mineral is, however, very complex, containing small quantities of many metals. In the process of separating the minute quantity of radium present in the mineral, advantage is taken of the fact that the salts of radium closely resemble the salts of barium, and that when a solution containing both metals is mixed with sulphuric acid the precipitated barium sulphate carries down with it the whole of the radium also in the form of sulphate. Radium is sold chiefly in the form of bromide, which is still very expensive, owing to the demand for scientific and medical purposes and the very limited supply.

It was Sir Lauder Brunton who first suggested the use of radium emanation as a possible curative agent in cases of cancer. Brunton was a very intimate friend of Ramsay's, the acquaintance dating from early school days. There was therefore a double interest which led Ramsay to take steps in the hope of adding to the limited quantity available for the use of the medical profession in this country. When the emanation was

first used all radium had to be procured from Austria. But in 1910 a mine in Cornwall was found near St. Ives, where there was a large heap of residues containing pitchblende. Ramsay began with his private assistant, Mr. Whitehouse, to work out a process, and, after trying it on a small scale, the mining company started a small factory in the east-end of London under the title "The British Radium Corporation." Mr. Whitehouse was appointed chemist, and Ramsay's only son, William George Ramsay, assisted him in the work. Ramsay himself was neither a director nor shareholder, but he acted as chemical adviser, his duties being to visit the works at intervals and test the products. On 7th January, 1911, he was able to say in a letter to Dr. Travers in India, "The radium work is in full swing and turning out more radium than I fancy will easily sell. Still they are getting £20 a mgm. for it. Whitehouse has done it well. The concentration of the ore is the chief problem." The manufacture went on for a year or more, when larger works were taken on the south side of the Thames, but about that time the quality of the ore declined and the output was reduced. The company was ultimately wound up.

At about the time that the corporation for the manufacture of radium commenced operations the Radium Institute for the therapeutic use of radium was founded. At first it was hoped that supplies might have been obtained from British sources, but the corporation and the Institute were entirely unconnected together, and it

was not found possible for the former to comply with the requirements of the latter. Negotiations therefore fell through and the Institute got its radium from Austria.

A new mineral, having radio-active properties, had been discovered in Ceylon in 1904. It contained a large percentage of thorium oxide, and hence received the name *thorianite.* On being heated or dissolved in dilute sulphuric acid it gives off a considerable quantity of gas consisting chiefly of helium. Ramsay secured several hundred-weights of this mineral, and with the aid of a chemical manufacturer proceeded to treat it by the process used in the case of pitchblende for the extraction of barium and radium.

This part of the product was investigated in Ramsay's laboratory by Otto Hahn. It was found that in separating the radium salt from the barium, the radio-activity became concentrated on the one hand into the least soluble portion containing radium, and on the other into the most soluble portion which was found to contain a hitherto unrecognised radio-element to which Ramsay gave the name *radiothorium.* The facts were published both by Ramsay and Hahn in 1905. Hahn then left London and went to work with Rutherford in Montreal, having evidently taken some of the same material with him. He soon discovered *mesothorium,* the parent of radiothorium, and published an account of its radio-active properties while keeping the methods of preparation and the chemical properties secret. Meso-

thorium preparations, equal in activity to radium, were soon put on the market in Germany. In 1910 the question of the chemical properties of mesothorium was investigated by Professor Soddy,[1] who found that mesothorium was non-separable from radium. Consequently the radium prepared from thorianite in Ramsay's experiments contained the mesothorium. And as mesothorium gives rise in its radio-active change to radiothorium the latter becomes associated, in the process of fractionation, with the thorium present from which it is non-separable. The radiothorium obtained by Ramsay and Hahn was therefore a new-born product formed during the process of fractional crystallisation.

[1] *Transactions of the Chemical Society*, 1911, p. 72.

CHAPTER VII

LATER YEARS

WHEN a man is approaching the age of sixty years he is often supposed to be looking forward with some eagerness to the time when he can retire from active life. In Ramsay's case, however, there was little sign of relaxation so far as the fulfilment of public engagements was concerned nor in the active pursuit of scientific research. Nevertheless, there were times when he had to acknowledge privately that the pace could not be kept up much longer. He had been within a few years President of the Society of Chemical Industry (1904), President of the Chemical Society (1908 and 1909), President of the International Congress of Applied Chemistry (1909), President of the Chemical Section of the British Association (1897), and President of the Association itself (1911), and each year of office required a presidential address.

He had also been to India on official business (1900), and with the Society of Chemical Industry to the St. Louis Exhibition, with an address at the Congress of Arts and Science at St. Louis (1904), to Norway to visit

a mine of radio-active mineral, to lecture in Vienna (1908) at the Association Helvétique at Geneva, at the Association Française (1908), and at the Sorbonne. He was a member of the Sewage Commission also, which involved many journeys of inspection beside laboratory work at home. These and many other engagements were fulfilled while continuing his teaching and research at University College.

The Sewage Commission began operations in 1897 under the chairmanship of the Earl of Iddesleigh, the other members, beside Ramsay, being Sir Richard Thorne Thorne and General Phipps Carey (representing the Local Government Board), Mr. C. P. Cotton (Irish L.G.B.), Sir Michael Foster, F.R.S., Colonel T. W. Harding (West Riding Rivers Board), Mr. P. W. Killick (Mersey and Irwell Rivers Board), and Dr. J. B. Russell (Scottish L.G.B.). The commission was at work up to the time when its operations were suspended at the outbreak of war in August 1914. On the death of Sir Michael Foster in 1907, Ramsay, in a letter, reminds his friend Dr. McGowan that no fewer than five members of the Commission had already been removed by death; there were consequently a good many changes in the course of its existence. The staff employed consisted of Professor Sir R. Boyce (who died while the Commission was sitting) and Dr. A. C. Houston as bacteriologists; Dr. George McGowan and Mr. Colin C. Frye as chemists; with Mr. G. B. Kershaw as engineer. There were also a good many assistants, bacteriological and

chemical, and some ten reports were drawn up. In fairness it should be stated that one of the Appendices contained an account of the work "On the Pollution of Estuaries and Tidal Waters," by Dr. W. E. Adeney and Professor Letts, and that Dr. Adeney's original work, done before the Commission came into existence, was of fundamental importance and was only extended and amplified by the investigations made by the Commission. Obviously the membership of such a body could be no sinecure, and Ramsay in characteristic manner took a very active part in all the proceedings, which spread, as already indicated, over the long period of 16 to 17 years. He was greatly disappointed that no permanent body was established to continue enquiry, supply information, and make regulations bearing on the many important questions involved.

In 1904 Ramsay became President of the Society of Chemical Industry, a body consisting of about 5000 members and having a section established in New York. The opening session of the annual meeting was held on this occasion in the Columbia University, New York, commencing on September 8th, but the president and a large number of members proceeded afterwards to Philadelphia, Washington, Pittsburg, St. Louis (where they visited the exhibition), Chicago, Detroit, Niagara and Buffalo, and finally Boston. On October 5th Ramsay returned to England by the S.S. *Baltic.* Any one who has had experience of American enthusiasm

and hospitality, will feel his remark justified, when in a letter he wrote, "I had a very hard time, amusing enough, but at it from dawn till midnight, and often two speeches a day of the after-dinner type to the same audience for the most part. It was difficult to keep cheerful and lively under the circumstances."

The subject of his address to the Society was the "Education of a Chemist, and on some suggestions as to methods and practices by which science and scientific men may be made more serviceable to industry." With regard to the training which should be provided for young men who propose to become scientific or technical chemists, he believed that what he called the inventive spirit can be developed in most of them. That is to say, the training in methods of research and the cultivation of this attitude of mind is best effected by example. With this end in view every teacher from the senior professor to the youngest assistant must be occupied in research. Beginners, however, should be taught by themselves and should not begin research practically till after a preliminary year spent in analysis in making preparations and in physical operations. Above all there must not be too much teaching. The essence of scientific progress is the well-worn method of trial and failure. A little time is no doubt lost at first, but the ultimate rate of progress is much more rapid. The junior staff in a school or college ought to be encouraged to do research, and their duties should be so arranged as to afford time and facilities for such work. These

are the men who after a few years should readily find employment as works chemists.

As to the professor, he should know what every man in the laboratory is doing, and it is obvious therefore that the number of workers he can supervise is limited; Ramsay put the number at 40 or 50. Of course there is nothing to prevent his lecturing to a much larger number. The greater part of his time should be given to research, and this consideration leads to a review of the methods of selecting among candidates for such appointments, and generally to the government of universities. He then proceeded to discuss the question as to whether graduates only should be made assistants. "The older I get the less I believe in university degrees as a test of capacity." This utterance is obviously connected with his objection to examinations which are here reiterated.

The address at St. Louis was entitled "Present Problems of Inorganic Chemistry," and was printed in full by the Smithsonian Institution. He therein declares that

"the fundamental task of inorganic chemistry is still connected with the classification of elements and compounds. . . . Whatever changes in our views may be concealed in the lap of the future, the great generalisation due to Newlands, Lothar Meyer and Mendeléeff will always retain a place, perhaps the prominent place, in chemical science.

Now it is certain that no attempt to reduce the irregular regularity of the atomic weights to a mathematical expression has succeeded; and it is, in my opinion, very unlikely that any

such expression, of not insuperable complexity, and having a basis of physical meaning, will ever be found. I have already, in an address to the German Association at Cassel, given an outline of the grand problem which awaits solution. It can be shortly stated then: While the factors of kinetic and of gravitational energy, velocity, and momentum on the one hand and force and distance on the other are simply related to each other, the capacity factors of other forms of energy—surface in the case of surface energy; volume in the case of volume energy; entropy for heat; electric capacity when electric charges are being conveyed by means of ions; atomic weight when chemical energy is being gained or lost—all these are simply connected with the fundamental chemical capacity, atomic weight or mass. The periodic arrangement is an attempt to bring the two sets of capacity factors into a simple relation to each other, and while the attempt is in so far a success, inasmuch as it is evident that some law is indicated, the divergences are such as to show that finality has not been attained. The central problem in inorganic chemistry is to answer the question, Why this incomplete concordance?"

This question still remains incompletely answered notwithstanding the important advances which have resulted from the observations, especially of Soddy, Fajans, Fleck and Russell, on the existence and properties of isotropic elements, that is, of elements which are not identical as to atomic weight though occupying the same place in the periodic scheme and are not separable by chemical means from one another. Two varieties of lead, for instance, exist in nature. The skill of the best workers on atomic weights has thus been severely tested.

There are many other questions raised in this address

of Ramsay's, some of which he would no doubt have stated somewhat differently at a later date in view of the extension of knowledge which has taken place in the twelve years which have elapsed since the lecture at St. Louis.

It was in the same year 1904 that Ramsay received the Nobel prize for chemistry in the same year that the Nobel prize for physics was awarded to Lord Rayleigh. It is perhaps appropriate to recall the fact that names may be submitted to the Nobel Committee of the Swedish Academy only by a strictly limited number of persons, and a statement of the claims of the person whose name is proposed involves the preparation of a carefully considered document. There can be no impropriety now in mentioning that Ramsay's name was proposed to the Swedish Committee by Lord Avebury, as a member of the Swedish Academy, and the proposal was supported by the signatures of the leading English chemists. But it is probably not known generally in this country that a separate and entirely independent proposal was sent in to the Academy by Professor B. Brauner, of Prague. The statement drawn up by Professor Brauner occupied nine foolscap pages, and gives evidence of the characteristic enthusiasm of its author. Naturally he lays particular stress on "the discovery of one whole missing group of elements in the periodic system of Mendeléeff and the production of helium from or through the radium emanation."

A letter from Stockholm, dated 9th December, to Mr. Fyfe gives an interesting account of the journey thither.

"We left London the day before yesterday only, and it is as if we had been away for months. The North Sea was mizzly, grey, but calm. We saw the Dutch sabots and bunchy petticoats by lamplight as we reached Flushing: then we dined on the train, took our sleeper and slept through Germany, getting to Altona near Hamburg at 7.30 a.m. Then we ate and admired a huge statue of two horse-men fighting for the possession of a fish. Then to Kiel, which we reached in an hour and a half and found in brilliant sunshine. There are huge ship-building yards covered in with glass, and they are busy, evidently. We sailed to Korsör in Denmark, a sail of about five hours. We counted at once 28 German men-of-war, cruisers and torpedo boats, and we saw at least another 20 in the harbour. There wasn't another boat, not even a fishing boat, in sight. What is all this for? To guard commerce? There wasn't a sign of it. But the Baltic canal is now ready, and this is a nice little pond to manœuvre in when there is nobody to look on. The ships were evidently doing something, signalling with flags, putting about and about and up to some game. But, of course, we couldn't understand the game. Was it practising for a future meeting with England? We had brilliant weather, cold, but a warm sun. About 3.30 we got into narrower waters and saw Denmark on both sides. Then into the train at Korsör, and in two hours we were in Copenhagen. In these parts it gets dark at about 4.30, so we saw little of Copenhagen during our drive—a long one—to the next boat; for we crossed to Malmö in Sweden in the funniest boat I ever saw. It carried two lines of rails laden with trucks. And we had a meal of sorts, the table loaded with food but no waiters, and people crowded round, so that we had to ask for all we wanted,—cold meat, cold fish and what they call

Delicatessen in Germany, *i.e.* pickles, salt fish, jam, ham, sausages, etc. We filled up, however, and stood on a gangway above the trucks and looked at the lights of Malmö. Then a second night in a sleeper, quite comfortable except that it was so warm that we opened the window, and next morning, *i.e.* this morning (but it looks a week ago), there was 6 inches of snow on the foot of my bed! We passed through very pretty country this morning, broken and full of lakes, birch trees and red wooden houses. The lakes were all frozen and people sledging on them. Then at 9.30 Stockholm. M. made me invest in a lordly fur coat, and it was welcome here, for the thermometer is a long way on the wrong side of freezing. There was a deputation to meet us and put us on our way to the hotel. . . . Here we found Lord Rayleigh, who left the evening before we did; and also another prize-winner, a Russian physiologist named Pavloff, with his wife. . . . We have been driven all over Stockholm to-day by a celebrated mathematician, Mittag-Leffler, a great friend of the Russian mathematical girl who made a great stir some years ago. To-morrow the ceremony takes place. . . . I believe we get our prizes from the hand of the king, and that he is to be at our dinner party to-morrow. It begins at 10.30 p.m. Goodness knows when it will end. However, it will be a thing to remember."

From Stockholm the Ramsays went to Kandersteg in Switzerland, and on 27th December he wrote to the same friend as follows:

"We had a most gorgeous time for nearly a week, dining with all the celebrities, including old King Oscar. The old gentleman was very kindly and took Lord R. and me into his private room and showed us all his curiosities, the portraits of his sons when they were children and his reliques of Gustavus Adolphus and of Charles XII. The Crown Prince told Mag that it was a difficult job to be a king, thereby confirming the Swan of Avon. He said

19, Chester Terrace,
Regent's Park, N.W.

20th March, 1908

Dear Tilden,

You know my views about women in the Chem. Soc. I don't see why they shouldn't take part in all the business of the Society, & sit on the Council if elected. But I don't think it is worth an expenditure of £400. If however they are pleased with an associateship, that might solve the difficulty.

I quite approve of the circular, & return it. I shall be at the dinner.

Yours sincerely

W. Ramsay.

Facsimile of Letter.

that whatever one supposed that a Norwegian would do he invariably did the opposite. Indeed there was nearly a bloodless revolution while we were there; the Prime Minister of Norway was there, and I believe the dilemma was only postponed."

In the Presidential Addresses to the Chemical Society in 1908 and 1909 there are utterances on questions which are somewhat cognate to the subject of the address at St. Louis already quoted. In the former occur the following passages:

"Like most other chemists and physicists I choose deliberately the mechanical explanation of nature. We assume on what we consider to be good grounds the existence of molecules and of atoms. We believe on reasonable evidence that gases consist of almost innumerable molecules which may, like argon and its congeners, be single atoms, but which are usually groups of atoms. We hold that, as a rule, liquids consist of molecules of the same order of complexity as gases, but with smaller free path; the molecules of a liquid are more crowded than those of a gas. Some few liquids—water, the alcohols, the acids, probably salts and some others—may be regarded as mixtures of polymerides of their gaseous molecules. Of the structure of solids we are only beginning to have some crude notion.

We also believe that molecules at the ordinary temperature are in enormously rapid motion; that they are in frequent collison with each other, and that chemical action is the occasional result of such collisions, . . . but the process of combination is a comparatively slow one, and it is curious to think that a collision which is followed by a combination is a comparatively rare event. . . . What is meant by chemical action? We can represent it as a loss or gain of energy, but we also regard it as the union or junction of atoms, or it may be the dissolution of such union or the readjustment of unions, so that bodies with new properties

are formed. We may next ask what mechanism can be devised to give us a picture of the union of two atoms? . . . Various chemists have called the mechanism by which it is conceived that atoms remain associated in a compound 'affinities' or 'bonds,' and 'valency' is a word used to express the number of such 'bonds' which an element can exercise in any particular combination. I have to bring before you a suggestion which, although not exactly new, admits of definite statement, and affords a mental picture of what may conceivably take place. It is not a 'theory'; I do not hope that it may be true; it is rather a hypothesis, a supposition that I expect to be useful; it may be a 'make-believe'; I trust that it will not be a 'mistake.'

The hypothesis admits of short statement. It is: electrons are atoms of the chemical element electricity; they possess mass; they form compounds with other elements; they are known in the free state, that is, as molecules; they serve as the 'bonds of union' between atom and atom. The electron may be assigned the symbol E."

Ramsay then proceeded to quote from the Faraday lecture given before the society by Helmholtz in 1881 and a lecture by Nernst twenty years later. Both these authorities supported the idea of the dual nature of electricity. Ramsay, however, proposed to revert to the "one fluid" idea of Benjamin Franklin which has gained probability since the investigations of J. J. Thomson and the discovery of radio-active bodies.

"It has been shown that electric corpuscles or electrons are capable of detaching themselves from matter and inhabiting space unattached to any object. . . . The electron may be termed an atom of negative electricity. The atom which it has left is generally, and by many supposed to be always, positively electrified. . . .

Now I would argue that in the light of modern knowledge we must suppose that the terms 'positive' and 'negative' mean merely 'minus electrons' and 'plus electrons'; that the sodium ion or 'sodion' is an element, that the metal sodium is a compound of the element 'sodion' with an electron; that the chlorine ion is a compound of an electron (actually of more than one electron) with an atom of chlorine."

With the use of the symbol E he then proceeded to explain the constitution of common salt, which would be written NaECl, and that of other compounds, and to show in detail how chemical changes must be thought of and how they may be represented.

The second address to the Chemical Society in 1909 treats of the problems connected with the possibility of transmutation of elements into one another. The various arguments are stated in the following words:

"1. The subtraction from or addition to an atom of an element of one or more electrons by virtue of which it is converted into an ion completely changes the properties of that element.

2. The fact is incontestably proved that certain elements termed radio-active are losing electrons, and are thereby being converted into other forms of matter which in our present nomenclature have equal claim to be considered elementary.

3. The influence of ultraviolet light on many if not all elements is manifested in causing them to emit electrons; it is not, however, thereby proved that they yield other elementary forms of matter.

4. The effect of chemical change is usually manifested in a gain or loss of energy. There is reason to believe that change from one elemental form of matter into another would be accompanied by an unusually large gain or loss of energy, for it is known that the 'degradation' of radium is coincident with the

loss of a relatively enormous amount of energy. This energy, moreover, is in a highly concentrated form; much energy is contained in small volume or, what amounts to the same thing, in small mass, using the word in the sense of quantity of matter.

5. It appears that the irregular regularity of the numbers representing the atomic weights can be represented on the hypothesis that the addition or subtraction of definite groups of electrons is the cause of their divergence from a perfectly regular series.

These arguments, however, can be regarded only as furnishing strong ground for experimental investigation."

The rest of the address is occupied with an account of what has been done. This part of the subject has already been referred to at sufficient length in a previous chapter.

In 1909 the International Congress of Applied Chemistry held its triennial meeting in London. Ramsay was president, and a large part of the necessary preliminary work fell on him and Lady Ramsay. The congress opened on May 27th in the Albert Hall, with the Prince of Wales (King George V.) in the chair. On his left were the Princess of Wales, Dr. Wiley (chief representative of the United States), then M. Armand Gautier (representing France) and Professor E. Paternò (representing Italy). On his right were Sir Henry Roscoe (Honorary President), Ramsay (Acting President), Professor Otto N. Witt (Past President of the Congress) representing Germany and Professor Svante Arrhenius representing Sweden. On the platform were many ambassadors and other distinguished men. After-

a speech of welcome from the Prince, Roscoe addressed a few words of welcome to the foreigners and of thanks to the Prince and Princess. Ramsay followed, recalling the fact that the first congress took place in Brussels in 1894. The last meeting was in Rome, where the King of Italy was pleased to fill the position occupied by the Prince that day. In the course of this speech he pointed out that the industrial prosperity of a country can best be advanced by a close association between the technical and the scientific workers, between the university and the factory, between pure and applied science. This principle had been recognised and acted on much more completely on the continent of Europe than in this country or in America. He then addressed words of friendly greeting to the foreign delegates in French, German and Italian successively. The entertainment afterwards given included a reception by the Lord Mayor in the Guildhall and by the government at the Foreign Office. There was a banquet to 2000 people in the Crystal Palace, at which of course Ramsay had to preside and which for so enormous a gathering was pronounced a success. There was also a garden party in the Botanical Gardens, Regent Park, given by the committee of ladies organised by Lady Ramsay, who also arranged for a body of girl guides speaking various languages to conduct parties of the foreign ladies present at the meeting to see the wonders of the town.[1]

[1] A full report of the proceedings was given in the *Chemical News*, 4th June, 1909.

When it was all over Ramsay naturally felt the effect of the strain, and in the late autumn he was ordered off for a voyage, and in November, accompanied by his old friend Mr Fyfe, he went to Rio de Janeiro, returning after only a few days' sojourn in Rio. In 1911 Ramsay became President of the British Association. In a letter to Mr. Fyfe, 19th July, he writes :

"I have finished my B.A. address this afternoon and now holidays begin. I think I feel the difficulty of such work more and more; it is harder and harder to do more than one serious thing at a time. My friend X complains of not being able to do more than eight hours' work a day and asks me how to pass his evening hours. He wants to know whether it would be possible for him to learn to smoke! Some folks find cards a relief; I don't. I find reading all that I want or need."

In the previous May Sir William and Lady Ramsay had made an excursion to Algiers, which he described in a letter to Mr. Fyfe as follows :

"We sailed from Southampton to Algiers in the Dutch boat. On board were the Duke and Duchess of Wellington and their daughter. You may remember that his grandfather got a grant of land in Granada and a title after the peninsular war, and the present Duke goes out every year to look after it. They left us at Lisbon. Mag and I landed and went up to the fort on the hill. A young soldier showed us round and we saw a good deal. His Portuguese was a bit difficult to make out, but we managed. Then we went to Belem and saw the church and the school. The revolutionists have done a good deal of damage; a lot of buildings have been battered about. We spent a week in Algeria. After three days in the town of Algiers we went to Relizane, a little place south-west of Algiers, and then by motor

Sir William Ramsay in 1912.

to see the oil-boring of the Algerian Oil Company. . . . The country is curious; low hills mostly cultivated by Arabs; wheat and vines. The water-courses wash away vegetation, so the nullahs, I suppose one would call them, are muddy, but bright with flowers. Very little green. The Arabs and the French appear to hit it off perfectly. . . . I was surprised to find Algiers so French. Outside the actual Arab quarters it might be outskirts of Paris. Then we went to Marseilles and on to Paris, where we spent ten days. Every day we lunched or dined out; it was very pleasant, but we had quite enough of it at the end."

The address at Portsmouth was naturally taken up to a large extent with an exposition of current views as to the nature of the chemical elements and the possibility of transmutation. The latter part of the discourse, however, consisted of a vigorous and convincing remonstrance against the national waste of energy in the extravagant use of coal.

At the end of the summer session of 1912 at University College Ramsay retired from the professorship. He was still in search of a suitable house in the country, and it was not till October in the following year that he could announce to his friend Fyfe the purchase of the house at Hazlemere, two miles from High Wycombe. As some alterations were necessary, a lodge and garage to be built and the conversion of the stables into a laboratory, it was not expected that the place would be ready for occupation before January. As a matter of fact it was much later.

On his retirement a portrait, painted by Mr. Mark Milbanke, was presented to University College by the

staff and students, who thoughtfully provided a replica, which on the same occasion was presented to Lady Ramsay. Another portrait, by Mr. Dick Peddie, was a gift to the family by Sir Dorabji Tata and Sir Ratan Tata, sons of the founder of the Indian Institute at Bangalore. It was painted in the winter of 1915-16.

In the previous summer (1913) Ramsay had been to Birmingham to attend the meeting of the British Association and afterwards for a week to Brussels, where he presided over the International Association of Chemical Societies. He wrote

"it was very hard work conducting affairs in three languages; but it went off all right, and we separated having done a good deal of useful work."

A letter of 29th December shows that he had been working at polonium and among other things

"I am grinding away at old Black's[1] letters; I am going to publish a book with Constable; a short life; an amplification of the discourse I gave in 1904.[2] Some of the letters are very interesting. Time doesn't hang heavy on my hands; to-day I had two hours of proofs of a 2d edition of one of my books in German."

On the 19th July, 1914, he wrote, "we are now fairly settled in and have some idea of how our new life will pan out." Alas for the vanity of human wishes and anticipations! The same letter on another page announces that

"We are going to Havre on Saturday. Do you remember I went on there after the ever memorable visit of Smith, Marshall,

[1] This was, of course, Joseph Black, Professor of Chemistry in the University of Edinburgh, 1766 to 1797.

[2] In Glasgow.

you and me to Paris in '77? The French Association meets there, and it has asked those of the B.A. who haven't gone to Australia to be their guests. I have to make a speech at the opening meeting on Monday, which I have written out and will read. They were very nice to me in '77 as a youngster; I was the only Englishman there, and at a dinner I got a highly honorable place. After the F.A. we shall go to some little place on the coast and have some bathing."

The next letter is dated c/o W. R. Langstaff, Havre, till 27th July, 1914.

"We got here on Saturday morning after a stormy passage; but we all slept well. . . . To-day our proceedings commence in the theatre at 2. There are to be speeches by the Maire, the President (Gautier, an old friend of ours) and me. I have written it out and will read it. It isn't long; it treats of international amity, etc. I am afraid there isn't much promise of an interesting meeting, judging by the programme. About 100 B.A. sen. people are here or to be here. . . . After we leave the Langstaffs we are going to a little hotel—Des Bains et de la Plage at Les Petites Dalles, Seine Inferieure, to try to get some bathing."

The next communication to Mr. Fyfe was a card dated 2nd August, 1914:

"I am afraid all plans for the present are at an end. We must just 'wait and see.' I fancy we should have left Havre yesterday, but we thought things would hang fire for a day or two. In the meantime mobilisation is declared here, and we must cut and run or else get a *permis de séjour*. The trains are all blocked with soldiers going to the frontier, and I am afraid we shall be detained here some days, We shall get back by Havre. There are hardly any French here now; only a few stranded English families. The final meeting of the French Association took place on Friday, and I thanked them for hospitality."

The Ramsays were able to get home without serious trouble, as narrated in a letter from home to Mr. Fyfe on the 11th August:

"We had no hardships at all; I commandeered the hotel motor which had been away—caught by the army authorities—for three days. The moment I saw it I bargained with the chauffeur, and for the moderate sum of 120 francs he agreed to put us and our luggage into Havre—about 60 miles. We started off on Thursday morning at 6 a.m. We were stopped twice by outposts, but we had a *permis de séjour* also a *permis de voyage*, so they let us pass. We got to Havre at about 10.30, and Langstaff, who is agent for the L. & S.W. Ry. Co., told us to go straight to the boat for it was sailing at 11.30—the last chance. However, when we reached the boat, L. was there and he had a wire to delay it till 10.30 p.m. So we had a day in Havre. They were expecting British troops over every minute; the quays were crowded, and they were singing the National Anthem and the Marseillaise. Indeed before we reached Havre we were told that 30,000 English soldiers had landed. All the Solent is mined and we had a slow voyage up, arriving at 8 on Friday morning."

Needless to say Ramsay immediately devoted himself to work of national importance, the first step being to assist, through the Synthetic Products Company, of which he was a director, in the provision of acetone, a solvent essential in the production of cordite for which the country had been dependent on foreign sources.

The letter concludes, "Well it is going to be a big job. You and I never thought it would come in our life time, did we?"

Ramsay became a very active member of the Royal Society Committee. By the middle of 1915 he had made strong representations to the Government on the subject of the large supplies of fats and cotton which were finding their way to Germany through some of the neutral nations. As, however, it did not appear to be known in high official quarters that all fats are potential sources of glycerine, and hence of nitro-glycerine, a very powerful and extensively used explosive, and that cotton is necessary for the production of ammunition, much delay occurred with consequences which can be calculated only in imagination.

In a letter to his friend Fyfe on 5th February he writes:

"Last week I gave an address in Manchester at the annual meeting of the Employers' Parliamentary Association and talked to them about German trade methods. I will send you a copy. I am trying to rouse people to see that they must reply to commercial attack by combined defence; and I am trying to get America and France to join against Germany."

In May he paid a flying visit to his friends at Dunblane, but his letters about this time are full of matters relating to the war, and complaints of the inactivity of the Government and the stupidity of not making cotton a contraband article.

So long ago as 1886 Ramsay had mentioned in a letter to Mr. Worthington that he had discovered that the discomfort from which he had been already suffering was due to polypus in the right nostril, and that he had

undergone the necessary operation and was more comfortable. The trouble was, however, not permanently removed, and recurrences had happened, as is usual in such cases, in later years. It was probably this tendency which concealed too long the malignant disorder which just thirty years later put an end to his life.

On the 19th July, 1915, he reported to his friend Fyfe that he had had several huge polypi extracted from his left nostril. "I have stood them for years, one gets into the habit of bearing discomforts, but it is a great relief." This, however, was not to be the end of the mischief. Late in the autumn, when the Scientific Societies were resuming operations, his friends expected to see Ramsay very often. They were, however, to be disappointed, and one who heard rumours of a more serious kind of operation wrote to him and received the following reply :

> "I am sorry to say it is true. I was in the surgeon's hands on Novr. 10th and again on the 13th, and he did an operation on my left antrum for a tumour, I believe very successfully. Since then, last Monday, I was irradiated for 24 hours with X rays, as a precaution against recurrence. Luckily it is of the kind which can be stopped by radium. I have had a very bad time."

The hopes of the surgeons and the anxious anticipations of his friends were, however, doomed to disappointment. The trouble became more aggravated, and after many months of physical misery borne with a patience and quiet dignity which filled with admiration the

sorrowing watchers by his bedside, he passed away quietly in the early morning of 23rd July, 1916.

Ramsay's last communication to the scientific world is dated 1st April, 1916, and is entitled "A Hypothesis of Molecular Configuration in Three Dimensions of Space." It is, however, the result of experiments made some years previously. The paper is printed in the *Proceedings of the Royal Society*, issued 1st July, 1916.

CHAPTER VIII

VIEWS ON EDUCATION

As already mentioned Ramsay's own early education was obtained in a private school in Glasgow, and subsequently in the Glasgow Academy and University. His whole career thereafter was associated with university life. It is therefore obvious that such direct experience as he had of methods in education were derived from the Scottish school system and the Universities of Glasgow and Tübingen, in which he was a student. He was greatly and permanently impressed with the advantages of the German system as applied in his own case and that of his contemporaries. This may be taken to explain to a large extent his attitude as a university professor. His aim was throughout his life the extension of knowledge, and any system which did not seem to lend itself to this object had very little sympathy or approval from him.

His views on the subject of elementary and secondary school education may be gathered from an article published in January 1916, the last year of his life, by the Manchester *Daily Dispatch*. He says:

"Our present elementary school system dates from the passing of the Education Act in the middle of last century.[1] School Boards were then instituted and all primary education was made free. In the writer's opinion this was a fatal move. It was doubtless regarded as a natural asset that every boy and girl should learn to read and write and be acquainted with the elements of arithmetic, but this Act was the first to differentiate between the classes. In those piping days of peace the idea of a national army was far from the thoughts of our statesmen; yet it would have been well had some return been demanded from those on whom a benefit was being bestowed, and that return might well have been some obligation on everyone receiving education to serve his country. To bestow a privilege without requiring a corresponding service is poor business; it leads to pauperisation.

It was not long before 'payment by results' was introduced; the remuneration of the teacher depended largely on the number of children who could pass, during certain specified ages, 'standards,' their acquirements being tested by external examiners appointed by the State.

No worse system could possibly have been adopted. It fettered the originality of the teacher; it placed before him the almost impossible task of trying to equalise the attainments of children of very different tendencies and capacities, and, developed as it was by the pupil-teacher, it launched on the schools as teachers a set of people moulded in one mould. Doubtless many of these chafed under the rigid restrictions to which their teaching was subjected, but there was no redress; uniformity was the order of the day.

Later the system broke down and had to be abandoned. The children were no longer tested by external examiners; the inspectors were instructed to make general reports dealing with the efficiency of the schools under their charge. This change

[1] The first Elementary Education Act was passed in 1870 and was amended in 1903.

for the better still persists, but the old *régime* has left its mark on many of the teachers, and though many of the younger masters and mistresses have been emancipated the process is not yet complete.

An attempt was made to introduce science teaching into schools by the institution of the Science and Art Department. Teachers who so desired were able to obtain instruction in elementary science—physics, chemistry and botany—and in the rudiments of art by attendance at courses of instruction for a month or two in the year, their expenses being paid. It was possible for them to earn enhanced grants if they could impart to their pupils the information they had received, so as to enable them to pass certain prescribed examinations.

This system had something to recommend it, and in some cases, doubtless, good was done. But there is no royal road to learning, and with the best will in the world it is impossible to imbue a heterogeneous assemblage of young men and women in the course of a couple of months with more than a smattering of rudimentary facts.

It was these facts, or probably in most cases a travesty of them, which were imparted to the pupils by the teachers. Science is essentially experimental; its dry bones can be buried in books, but when disinterred and swallowed they are poor nourishment. Examination by examiners who have had no part in the instruction of the pupil, tests at the best a retentive memory and the power of assimilating phrases.

So-called 'practical examinations' do not help matters. They, too, become systematised and consist only in testing the ability of a pupil to remember some manual actions scarcely associated with definite meaning. The only practical examination possible is the daily examination of the pupil by the teacher, when all signs of intelligence are noted and education becomes a 'drawing-out' of the child's mind. British elementary education therefore, for the past half-century and more, has followed wrong lines.

But it is worth enquiring here whether the German ideal which requires the subject, in the words of the English Prayer Book, 'to do his duty in that state of life to which it has pleased God to call him,' without any hope of bettering his position; or the British ideal, a democratic one, to make it possible for every gifted boy and girl to climb the tree; to make it possible for the corporal to wield the marshal's baton, is the better of the two.

Although the methods employed have been lamentably defective, it must yet be acknowledged that the democratic ideal lay at the bottom of English educational efforts. Even the attempt at science teaching had its good side; it rested on the assumption that the children, at a later stage, would be able to utilise their attainments for their own benefit and for that of the State. On the other hand the German aim has been to create an efficient machine, where knowledge was reserved for those with the power to apply it and where the 'hands' were strictly and irrevocably differentiated from the 'heads.'

We are learning now, by bitter experience, how efficient this system is in war; in German hands it bid fair to be equally successful in commercial war. The socialistic movement, which was strong in Germany, was a protest by the people against this view of the organisation of a nation, the revolt of a people against repression. But the German nation as a whole has not been successful at rebellions; the spirit of drill has penetrated too deeply into the soul of the people, and for the most part the slaves are content with their bondage. Whether a change is to be looked for time alone will show.

Stated tersely the difference in the two ideals is that between individualism and collectivism. In Britain the spirit of collectivism exists; it has taken the form of trade unions, where compulsion holds sway and all individualistic effort is discouraged. But on the whole the British nation is individualistic; let every man have his chance.

. . . .

Secondary education in Britain has always been chaotic, and only of recent years have attempts been made to give it a semblance of order. Teachers in secondary schools have, for the most part, been untrained young men, whose only claim to enter the profession of teaching has been a university degree. From the grammar schools to the public schools the teaching has been conducted largely by amateurs. Of course among them have been some great schoolmasters, but though the result, on the whole, has been to turn out a strong, healthy, moral youth, that youth has been very ignorant of modern life and of scientific thought.

The older universities have accentuated these evils. Brought up in the shrine of classical learning, more attention has been devoted to form than to reality. Of recent years a change for the better has been taking place, but nothing is more difficult than to dispel the superstitions of centuries. The classical languages and literatures are in reality relics of a past state of civilisation. While they are, of course, valuable subjects of study and afford a certain kind of training, they are utterly out of touch with modern ideas. Few, very few, boys, perhaps not one in a hundred, attain sufficient proficiency in them to gain pleasure from them in later years; and many, like the writer, who spent his school and college days from the age of 7 to 16 largely in studying the classics, retain a few tags, a few lines of verse, and the power to decipher a Latin inscription with difficulty and to guess at the meaning of most of the words in a Greek phrase. It may be said that the training was good; perhaps it was. But the aim of training, namely the power of concentration, the exercise of judgment, and most of all the development of the inventive faculties, could have been attained infinitely better by substitution of almost any other subject for the classics.

We are reaping what we have sown. Our statesmen, with very few exceptions, have not the remotest idea of science, and

the writer could adduce instances where the most incredible assertions have lately been made and acted on, to the effect that we have played into the hands of the enemy, and all because our Government officials are not only ignorant, but have not even the saving grace to know that they are ignorant and to seek in the right quarters for scientific help."

Had he lived a few years longer, Ramsay would have recognised the conciliatory spirit in which the problems connected with education are now being envisaged. Amid the miseries brought on this country by the war, at least one benefit has emerged in the recognition, by all but the most prejudiced among the representatives of the long-established classical system in schools, that some knowledge of the external world and of the discoveries which have been made as to the relations of the earth and sky, and as to the forms and conditions of life on this globe, is indispensable to every educated man and woman. It is only those who possess some of this knowledge who are able to shake off superstition, to understand something of their own relation to the rest of the human inhabitants of the earth, and in fact to form a true theory of life. Ramsay was probably right in assuming that invention and discovery are the true keys to progress, and though it is not given to every one to add to the common stock of knowledge by undertaking the special kind of studies requisite for systematic investigation, discovery by others cannot fail to rouse some interest in every mind but the dullest. What is wanted is a reform in the attitude of the public mind which is too apt to ignore or to despise all knowledge

which is not immediately applicable to utilitarian purposes. The beauty and fascination of knowledge for its own sake is a source of happiness at present enjoyed by comparatively few.

Ramsay's views about education do not seem to have undergone fundamental alteration in the course of his life. The following extract from a letter addressed to his friend Worthington on 29th April, 1886, shows what he was thinking about at the age of thirty-four :

"I quite agree with you about the importance of spreading scientific knowledge. There are so many reasons why it is worth doing, as you say, for people's own sakes. But I think I also agree with you that it is only to be done in schools. I think popular lectures on science are mostly twaddle—or to speak euphoniously—a high-class amusement. The only good they do, so far as I have ever seen, is to induce some few to follow out the subject. Perhaps they are worth doing for the sake of the few righteous men. But have you realised that there is a special bent of mind which eagerly sucks in everything relating to external nature and another class which simply refuses, though well able to assimilate? For example, my wife and a great friend of hers, a Miss Burns, who once attended lectures to ladies I gave in Glasgow, and who came out easily first, having a clear mind and a good memory and great power of application; well both these good people absolutely refuse to see anything interesting in the matter. Both are interested in literary and philosophic subjects—anything mental in fact; but a physical fact does not appeal to their interest. Most men, I think, are like this. They pretend interest because they can't ignore the palpable results of applying science, but the things in themselves are absolutely without interest for them.

All the same I agree with you; but I think that an attempt

should be made to cultivate the weak part of many minds when young, and to get them to see the use of such things. When a fellow can see the drift of what he learns, then he is eager to learn what would otherwise be fearfully dry; and I should always try to begin with the application and then lead back to the methods, even though the whole thing had to be gone over again in reversed order,—methods first, then applications. I think that idea is rapidly growing. I am sure that the right plan is, to take an example, to teach geography by mapping a garden with the assistance of the child, and extending from the known to the unknown.

I remember that Martineau in an address lately said that he had tried to learn the things he didn't take to naturally, so as to balance his mind; being convinced that what he liked he would learn in odd times and almost without trying. I dare say a great swell like Martineau might take such liberties with himself, but I am doubtful if his method is generally applicable. My experience personally and of most others is that one has a dislike to learn anything. Do you think that is general? . . . I think a boy when he is set to find out the properties of a metal, say silver, through its salts takes leave of his sober senses and imagines he is beginning a series of magical transformations. I said to a fellow yesterday, 'Suppose you saw a sheep, how would you recognise it as a sheep?' He grinned and described a sheep. I then said, 'Now, suppose you saw its skeleton, how wd. you tell it belonged to a sheep?' He named feet and teeth. I then told him that he must learn to know exactly in the same sort of way various properties of silver, so that if he came across it he should recognise it again. I think he took me up. I often wonder that a fellow who apparently conducts the ordinary business of life sensibly should run amuck as soon as he tries a slight extension of his every-day experiments. I think the first thing to do is to eliminate the element of mystery which hangs round these things and show a fellow that he is as great a fool

when he makes a mistake of that sort as if he were to buy a hat four sizes too small. I agree absolutely about physics. I don't see any good in loading a boy's mind with the minutiae of chemistry. It is pure memory work and very dry. Some things I would teach—carbonic acid, water, air, etc.; in fact Lloyd Morgan has written a little book called *Things around us* which strikes me as the kind of thing wanted. But as you say, exact measurement is what is required as a training for chemistry. The chemical measurements are as a rule physical, but much more troublesome to understand. The chemistry a boy gets from the Science and Art teaching is really very useless. I often get such pupils and it means beginning from the egg. They have got up a certain number of text-book statements to order and haven't a ghost of a notion what the thing is all about. The only pull they have over the others is that the names are familiar. What is to be the upshot of all this? I think you are on the right lines; but are you not beginning at the wrong end?

I start with the axiom; no man can be a thoroughly good teacher who is not at the same time a learner; and in physical science that means an investigator. He is neither interested nor interesting and can't stimulate pupils to the same degree. Now who are the teachers? Graduates from Oxford and Cambridge,—mostly—at all events in the larger schools. These people are trained with a view not to be investigators, but as people who can understand and practise a certain examinational system.

Well I would begin at the top. Make preliminary exams. in science generally the condition of entering a science course at a university, and after one year (say at 18 or 19) finishing the regular examinational part of the course. I would give a degree for investigation. It isn't the originality so much that is required; it is the training in methods of thought and means of executing and realising ideas. That is what tells in life. It is the man who can improve and invent who should (if he doesn't) come to the

top, and such a man should be a graduate. Do that and you will affect the whole of the schools from top to bottom. It appears to me that the inventive faculty is the one most pleasant to exercise, and there your idea of pleasure comes in, as an end in science teaching. But only inventors can teach to invent, and discover the inventive faculty in others. Now I am afraid that is almost lost sight of in schools. I gave a paper to the Assistant Teachers and Pupil Teachers here some two months ago very much on these lines. . . .

I am afraid I have been rather discursive, but this letter has been written at several go-s."

Since this was written some steps have been taken toward the system of awarding degrees for research work at the University of London, and more recently at Oxford and Cambridge.

As already mentioned Ramsay held tenaciously to the view that examinations should be conducted by the teachers, and generally by the teachers only. He served a term as examiner at the University of London, where, of course, he had to administer a system which was not harmonious with his own opinions. But that he was a careful and sympathetic examiner is illustrated by the following extract from a letter, 24th July, 1899, to Professor Smithells :

"Do you know what Huxley once said about exams.? 'I don't care who sees the papers of those who are ploughed; but God forbid that any one should see those of the candidates who pass.' Perhaps if I tell you our plan of action, you will see how certain it is that no one who should pass escapes passing, while many who should fail pass.

In the first place there are 600 marks given for the two papers.

Everyone above 230 is allowed to pass, so far as these papers are concerned, without challenge. Those between 180 and 230 were viva'd; as a rule they improved their positions; but even if they didn't they were merely let alone, so far as marks go; for we took the view that nervousness might hinder their doing themselves justice. For the practical work 150 marks were assigned, and 50 marks passed all who had obtained written marks of over 200. There were so many (850) that if it happened that they had under 200 in the written but over 50 in the practical, they went, for we had no time to look into each individual case further. But remember that all over 180 got a chance of having their marks raised by the viva. So I think you will say that rejection has been justified where it took place. If they showed that they understood the method of the volumetric and had made a serious effort to get approximate numbers, they passed, for they were awarded 50 marks."

The following passage from a letter to Mr. Worthington, 19th November, 1901, relates to what is now merely a matter of history:

"I am depressed just now by possible proceedings in L.U. Roscoe and Rücker are being sorely tempted to truckle to the Technical Education Board of the L.C.C. and appoint Tom, Dick and 'arry of the Polytechnics as University teachers, without any regard being paid to their efficiency. I had a stiff argument (in private) with them last night, as to the condition which I have succeeded in carrying for admission as 'teachers' of the University; viz. that in the Science Faculty some proof of originality must be given before their claims are admitted. We have acted on this up to now; but Sidney Webb, who holds the strings of the L.C.C. money bags, is doing all he can to get recognition as 'teachers' for the present Board-School-ähnliche teachers, on the understanding that they will ultimately be replaced by efficient persons."

Ramsay had an opportunity of setting forth his views on the subject of university education in an oration delivered at University College on the 6th June in the same year. This was printed in the volume of *Essays, Biographical and Chemical*, which he published in 1908, and which was afterwards translated into German and issued in Leipzig by the Academische Verlagsgesellschaft under the title *Vergangenes und Künftiges aus der Chemie*. The second edition of the German version, published in 1913, contains the autobiographical sketch from which extracts have been quoted in a previous chapter. The last essay in the volume of *Essays* consists of the oration referred to, which is entitled "The Functions of a University." It occupies about twenty pages of print, but the following abstract will serve sufficiently to give the substance of the essay :

"I am about to speak of the Functions of a University. The word university has borne many significations ; and indeed its functions are various, and the signification of the word has depended on the particular point of view taken at the time. An eminent German, who visited me some years ago, made the remark after seeing University College : 'Aber lieber Herr College, University College ist eine kleine Universität.' So it is, for it fulfils most of the functions of the most successful universities in the world. . . . The traditions of University College have always been that it is not merely a place where known facts and theories should be administered in daily doses to young men and young women, but that the duty of the professors, assistant professors, teachers and advanced students is to increase knowledge. That is the chief function of a university—to increase knowledge. But it is not the only one."

He then proceeds to give an account of the founding of the college and of the business of the several faculties.

"We see then that a university, as it at present exists, provides, or may provide, technical instruction for theologians, for lawyers, for medical men and for engineers. It is in fact an advanced technical school for these subjects.

But it is more, and I believe its chief function lies in the kind of work which I shall attempt now to describe.

The German universities possess what they term a 'Philosophical Faculty'; and this phrase is to be accepted in the derivational meaning of the word—a faculty which loves wisdom or learning. The watchword of the members of this faculty is Research; the searching out the secrets of Nature, to use a current phrase, or the attempt to create new knowledge. The whole machinery of the Philosophical Faculty is devised to achieve this end; the selection of the teachers, the equipment of the laboratories and libraries, the awarding of the degrees.

. . . .

There are two views regarding the advantage of research. The first of these may be termed the utilitarian view. You all know the tale of the man of science who was asked the use of research, and who parried with the question—What is the use of a baby? Well, I imagine that one school of political economists would oppose the practice of child-murder on the ground that potentially valuable property was being destroyed. These persons would probably not be those who stood to the baby in a parental relation. Nor are the most successful investigators those who pursue their enquiries with the hope of profit, but for the love of them. It is, however, a good thing, I believe, that the *profanum vulgus* should hold the view that research is remunerative to the public, as some forms of it undoubtedly are.

The second view may be called the philosophical one. It is one held by lovers of wisdom in all its various forms. It explains

itself, for the human race is differentiated from the lower animals by the desire which it has to know 'why?'

. . . .

Now the most important function, I hold, of a university is to attempt to answer that question 'why?' The ancients tried to do so, but they had not learned that its answer must be preceded by the answer to the question 'how'? and that in most cases—indeed in all—we must learn to be contented with the answer to 'how?' The better we can tell *how* things are, the more nearly shall we be able to say *why* they are.

Such a question is applicable to all kinds of subjects; to what our forerunners on this earth did; how they lived; if we go even further back, what preceded them on the earth. The history of these enquiries is the function of geology, palaeontology and palaeontological botany; it is continued through archaeology, Egyptian and Assyrian, Greek and Roman; it evolves into history, and lights are thrown on it by languages and philology; it dovetails with literature and economics. In all these research is possible, and a university should be equipped for the successful prosecution of enquiries in all such branches.

Another class of enquiries relates to what we think and how we reason; and here we have philosophy and logic. A different branch of the same enquiry leads us to mathematics, which deals with spatial and numerical concepts of the human mind, geometry and algebra. By an easy transition we have the natural sciences; those less closely connected with ourselves as persons, but intimately related to our surroundings. Zoology and botany, anatomy, physiology and pathology deal with living organisms as structural machines; and they are based on physics and chemistry, which are themselves dependent on mathematics.

Such enquiries are worth making for their own sakes. They interest a large part of the human race; and not to feel interested in them is to lack intelligence. The man who is content to live from day to day, glad each day will but produce him food to

eat and a roof to sleep under, is but little removed from a uncivilised being. For the test of civilisation is *prevision*; care look forward; to provide for to-morrow; the morrow of the ra as well as the morrow of the individual, and he who looks furthe ahead is best able to cope with Nature and to conquer her.

. . . .

If attempts were made to discover only useful knowledge (a by useful I accept the vulgar definition of profitable, *i.e.* kno ledge which can be directly transmuted into its money eq valent), these attempts would in many, if not in most, cases f of their object. I do not say that once a principle has be proved, and a practical application has to be made of it that t working out of the details is not necessary. But that is b done by the practical man, be he the parson, the doctor, t engineer, the technical electrician, or the chemist, and best all on a fairly large scale. If, however, the practical end always kept in view, the chances are that there will be no advan in principles. Indeed what we investigators wish to be able do, and what in many cases we can do, although perhaps ve imperfectly, is to prophesy, to foretell what a given combinati of circumstances will produce. The desire is founded on a bel in the uniformity of Nature; on the conviction that what h been will again be, should the original conditions be reproduce By studying the consequences of varying the conditions c knowledge is extended; indeed it is sometimes possible to so far as to predict what will happen under conditions all of whi have never before been seen to be present together.

When Faraday discovered the fact that if a magnet is ma to approach a coil of wire an electric current is induced in th wire, he made a discovery which at the time was of only scienti interest. That discovery has resulted in electric light, elect traction and the utilisation of electricity as a motive pow the development of a means of transmitting energy of wh we have by no means seen the end; nay, we are even now o

at its inception, so great must the advance in its utilisation ultimately become.

When Hofmann set Perkin, as a young student, to investigate the products of oxidation of the base aniline produced by him from coal-tar, it would have been impossible to have predicted that one manufactory alone would possess nearly 400 large buildings and employ 5000 workmen, living in its own town of 25,000 inhabitants, all of which is devoted to the manufacture of colours from aniline and other coal-tar products. In this work alone at least 350 chemists are employed, most of whom have had a university training.

Schönbein, a Swiss schoolmaster interested in chemistry, was struck by the action of nitric acid on paper and cotton. He would have been astounded if told that his experiments would have resulted in the employment of his nitro-celluloses in colossal quantity for blasting and for ordnance of all kinds, from the 90-ton gun to the fowling piece.

But discoveries such as these, which lead directly to practical results, are far inferior in importance to others in which a general principle is involved. Joule and Robert Mayer, who proved the equivalence of heat and work, have had far more influence on succeeding ages than even the discoverers above mentioned, for they have imbued a multitude of minds with a correct understanding of the nature of energy, and the possibility of converting it economically into that form in which it is most directly useful for the purpose in view. They have laid the basis of reasoning for *machines*; and it is on machines, instruments for converting unavailable into available energy, that the prosperity of the human race depends.

You will see from these instances that it is in reality 'philosophy' or a love of wisdom which, after all, is most to be sought after. Like virtue, it is its own reward; and as we all hope is the case with virtue too, it brings other rewards in its train; not, be it remarked, always to the philosopher, but to the race.

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Virtue pursued with the direct object of gain is a poor thing; indeed it can hardly be termed virtue, if it is dimmed by a motive. So philosophy, if followed after for profit, loses its meaning.

. . . .

Of course it is necessary for a student to learn so far as is possible, what has already been done. I would not urge that a young man should not master, or at all events study, a great deal of what has already been discovered before he attempts to soar on his own wings. But there is all the difference in the world between the point of view of the student who reads in order to qualify for an examination, or to gain a prize or a scholarship, and the student who reads because he knows that thus he will acquire knowledge which may be used as a basis of new knowledge. It is that spirit in which our Universities in England are so lamentably deficient: it is that spirit which has contributed to the success of the Teutonic nations, and which is beginning to influence the United States. For this condition of things our examinational system is largely to blame. Originally started to remedy the abuses of our Civil Service, it has eaten into the vitals of our educational system like a canker; and it is fostered by the further abuse of awarding scholarships as the results of examinations. The pauperisation of the richer classes is a crying evil; it must some day be cured. Let scholarships be awarded to those who need them, not to those whose fathers can well afford to pay for the education of their children. 'Pothunting' and philosophy have absolutely nothing in common.

There are some who hold that the time of an investigator is wasted in teaching the elements of his subject. I am not one of those who believe this doctrine, and for two reasons: first, it is more difficult to teach the elements of a subject than the more advanced branches; one learns the tricks of the trade by long practice, and the tricks of this trade consist in the easy and orderly presentment of ideas. And it is the universal experience

that senior students gain more good from instruction in advanced subjects by demonstrators than juniors would in elementary subjects. For the senior student makes allowances; and the keenness and interest of the young instructor awakens *his* interest. Second, from the teacher's point of view it is always well to be obliged to go back on fundamentals. One is too apt, without the duty of delivering elementary lectures, to take these fundamentals for granted; whereas if they are recapitulated every year the light of other knowledge is brought to bear on them and they are given their true proportion; indeed ideas occur which often suggest lines of research. It is really the simplest things which we know of, the atomic theory, the true nature of elasticity, the cause of the ascent of sap in plants, the mechanism of exchange in respiration and digestion; all these lie at the base of their respective sciences, and all could bear much elucidation.

I believe therefore that it is conducive to the furtherance of knowledge that an investigator should be entirely engaged in teaching. But he should always keep in view the fact that his pupils should themselves learn how to investigate, and he should endeavour to inculcate that spirit in them.

It follows that the teachers in the Philosophical Faculty should be selected only from those who are themselves contributing to the advancement of knowledge; for if they have not the spirit of research in them, how shall they instil it into others? It is our carelessness in this respect (I do not speak of University College, which has always been guided by these principles, but of our country as a whole) which has made us so backward as compared with some other nations. It is this which has made the vast majority of our statesmen so careless, because so ignorant of the whole frame of mind of the philosopher; and which has made it possible for men high in the political estimation of their countrymen to misconceive the functions of a University."

The speaker then proceeded to discuss several other subjects, and the oration concludes with a statement of his objections to the predominant influence of examinations in English education. There can be little doubt from a comparison of dates and other circumstances that this oration was used as an opportunity of rejoinder to Lord Rosebery, who, as Vice-Chancellor of the University of London, had in the previous month (May 1901), at the meeting for conferring degrees, being called on to speak, allowed himself to give utterance to views of a wholly different character. For he declared in plain terms that in his opinion the university should teach, but should have nothing to do with research. Although this dictum was received by a considerable section of the audience with evident signs of approval, it certainly excited a great feeling of dissatisfaction in the minds of many persons present. Such a remark falling from the lips of a speaker of such eminence and holding a position of such authority in the university seems to show that at that time he had thought but little about the question. It stands out in marked contrast to the view expressed only a few weeks earlier by Mr. Joseph Chamberlain, then Chancellor of the then newly-constituted University of Birmingham, who exhorted the new university to aim at doing four things: it should teach, it should examine, it should add to knowledge by research, it should show the applications of knowledge. And this is practically the programme set forth in Ramsay's discourse.

CHAPTER IX

NOTES ON TRAVEL

RAMSAY was fond of travel, and devoted many of his holidays to excursions in Scotland, Norway, France, Germany and Switzerland. But there were also many occasions when business of some kind took him abroad, as when he went to lecture in Paris or Berlin, to preside over a meeting in the United States or Canada, to receive the Nobel Prize in Stockholm, or to India at the request of the Government. Some of these journeys have been already referred to and sufficiently described in previous pages. With regard to others it was felt that the continuity of the life history would be unduly interrupted by relating the details of all these journeys in proper chronological order. Accordingly a short account of each has been separately drawn up; the story of the wedding trip in 1881 has been written by Lady Ramsay, to whom also the following pages are indebted for an account of the first visit to Canada in 1884, to Finland in 1907, and to India in 1900-01. Professor W. P. Ker, of University College, who accompanied Ramsay to Iceland in 1895, has been good enough to tell the story

of their adventures in that distant region, and to his account have been added extracts from two letters sent home by Ramsay containing humourous and characteristic sketches of their fellow-travellers and of the journey outwards.

WEDDING TRIP, 1881

His family used to say that all Ramsay's trips abroad were arranged with a view to visiting new laboratories and old friends, and that scenery, places of historical interest and art treasures might or might not be thrown in if time permitted. The wedding trip was no exception to this rule. The fact that a new laboratory was shortly to be built at Bristol made the inspection of laboratories specially interesting and important. The original plan was to spend August abroad and return to Clifton early in September to house-hunt, buy furniture, and get the laboratory in trim for the next term's work. The question of the principalship was to have been settled at a special meeting of council on August 10th, but there was so small an attendance that the committee of recommendation which had fixed on Ramsay would themselves have formed the majority, and the matter was again postponed till the end of September, just before the beginning of term. As this would influence the choice of a house, it was useless to start house-hunting, and Ramsay felt it was better to stay away —so as not to seem to influence the decision of the council. As regards the preparations for the term's

work, this had its inconvenient side, but Dr. Adrian Blaikie, at that time Ramsay's assistant, shortened his vacation like the loyal friend that he was, and made all right in the absence of his chief.

The wedding took place on August 3rd, and had the family been superstitious they might have felt that things looked bad for the future. Two days before the ceremony a maid in the Buchanan household developed diphtheria, and anxiety was felt lest Mrs. Buchanan should do the same. This, however, proved a false alarm, and as it was considered safer, arrangements were made to have a hotel wedding, a very unusual thing in those days. Troubles, however, were not over yet! Mr. and Mrs. Ramsay had invited the nearest relatives to dinner in the evening. On the morning of the wedding day, just after breakfast, the ceiling of their dining-room, for no obvious reason, crashed down —doing, happily, no damage beyond breaking a little china. Again arrangements were made rapidly, and an ingenious builder rigged up a canvas ceiling, and the party went off as if nothing out of the way had happened.

This chapter of accidents, instead of being an omen of evil, was the beginning of a singularly happy married life.

After a day or two in London the couple, both being fond of the sea, crossed to Antwerp from the Thames, saw Brussels and stayed a few days with Ramsay's old friend Elizabeth Lang, now Mrs. MacNicol. Her husband, an engineer, was getting some work done at the

great iron and steel works of Messrs. John Cockerel, and through his influence Ramsay saw over this wonderful factory, an experience which he never forgot.

After that Bonn, Heidelberg and Stuttgart were visited, and all new arrangements and apparatus taken note of for future use. The summer of 1881 was very wet, and during the whole of the tour there were only about ten days of fine weather. These fell luckily at the time of a small walking tour in the Eiffel, which Ramsay had once visited before and wanted to explore more thoroughly. It must be owned that it was a walking tour by courtesy only, for the journeys were for the most part made by all sorts of conveyances, and the walking was done in the surroundings of the various halts. The means of locomotion were rather peculiar. One day (it was wet) the local butcher's "wagen" was hired. It turned out to be one of the long German carts with two boards as a floor and two long things like ladders as sides, and, of course, not a vestige of a spring. Another day appeared a sumptous and evil-smelling four-wheeled cab, evidently the state chariot of the neighbourhood. The stopping places were also varied and full of interest. In one place the little inn was an old watch-tower, and all the rooms were round or the segments of a circle. All were out of the common. The last halt before getting back to much-needed luggage and change of raiment was, as ill-luck would have it, at the most select and conventional hotel in a most select and conventional little German watering place,

where every one changed their garments several times a day and looked askance at the "mad English" who arrived with only what they could carry.

Tübingen was not forgotten, and Ramsay had the pleasure of introducing his wife to old Mrs. Kommerell and her family. This was the last time he saw his old friend, as very soon after that she died and the home was broken up.

It did not, however, end his interest in her children, and indeed the last time he was in Germany, in the spring of 1913, he went out of his way to go to see the youngest daughter and make the acquaintance of her husband and family.

Before going to Tübingen the couple stopped a night at one of the large towns on the route, to visit one of his fellow-students, whom he had described as the most beautiful human being he had ever seen. Alas, the passing of the few years since they had parted had changed him into a fat, prosperous, elderly German citizen with not a vestige of his former charms.

Switzerland was next on the programme, but the rain it rained every day, and after a week or two of hoping it would clear, they gave it up and finished their holiday in Paris till it was time to repair to Bristol and learn what had been decided about the principalship, and to settle down in what was to be their home for the next six years.

BRITISH ASSOCIATION IN CANADA, 1884

After the wedding-tour the next long journey was the visit to Canada and the States in 1884. When it was proposed to hold the meeting of 1884 at Montreal the Ramsays were much tempted by the idea. Not only did they want to see our great over-seas dominion, but also a brother of Mrs. Ramsay's, a great friend of Ramsay's, who had been some time in the States, and they wished to meet him and see something of his life.

In the first place this occasion brought home to Ramsay the great value of the meetings of the association, not only in spreading an interest in the progress of science, but in bringing together scientific men, old and young, in circumstances where each had leisure to be interested in each other's work and ideas.

Like other young professors, he had visited the laboratories of the older and larger universities in vacation time, and found the heads either away or, if at home, they had stayed to work and visitors were rather a hindrance. Later, when the younger men came to see him in this way it was a real trouble to Ramsay when he had not really time to spare to give to them. The meetings of the British Association he felt met this difficulty. There the younger men could hear the older men speak and make their acquaintance, and the older ones could listen to the theories and fancies of the younger, coming men, and give them kindly words of criticism and encouragement.

Another important outcome of this journey was the forming of a sort of union among the heads of the University Colleges.[1] Several of these went to the association, and they talked over things so satisfactorily that they arranged to meet for the future at regular intervals, and act in concert in appealing to the Government for recognition and aid. It took time and trouble, but within five or six years they had a grant for endowment given by the State, and now they are nearly all independent universities.

Another reason for it being a memorable journey was its influence on Ramsay's friendships. Some slight acquaintances became real friends, and some friendships were formed that were to colour his life. Among those last was that with Professor George Francis Fitzgerald, of Trinity College, Dublin, which was of the closest and most intimate character for the next seventeen years. Fitzgerald was at this time about thirty-one years old (Ramsay's own age), but his prematurely grey hair and beard gave him the appearance of a much older man. The work he did in physical and mathematical science has been told in Sir Joseph Larmor's memoir, but no one can put on record all he did for science in helping and encouraging others in their work. No trouble was too great for him to take, and when less gifted men were puzzled by seeming contradictions in their results he threw himself heart and soul into their difficulties and, with his great mathematical power,

[1] An account of the proceedings will be found on page 91.

made the dark places plain by finding formulae to fit the new facts. This is the experience of, not one but of scores of his friends and even casual acquaintances. Ramsay felt always how much of his success was due to Fitzgerald's help, criticism and encouragement.

About the middle of July the Ramsays sailed from Liverpool in the *Parisian*, a month before she was to cross the Atlantic with the main body of the association on board. Among their fellow-passengers were Professor and Mrs. Viriamu Jones, Principal of Cardiff University College; Mr. and Mrs., now Sir Frederick and Lady, Pollock; Mr. and Mrs. John Albert Black, both of them old friends of Ramsay and his wife, and many others.

Before starting Mrs. Ramsay had heard from her brother that he was leaving California and meant to settle further north, and he suggested that they should meet in Montana and go through the Yellowstone Park, which was then in process of being settled up. Their plans were to go to Montreal and there find out all that was possible about the Yellowstone and how to get there and back before the meeting of the association. Among others on the *Parisian* were Professor Liveing and Dr. Campion, of Cambridge, who also hoped to see the Yellowstone. Professor Fitzgerald was also on board, but as he was a very bad sailor he did not appear till the voyage was nearly over. He also had the Yellowstone in view, and the day they arrived they all visited the various offices to try to make arrangements.

The Canadian Pacific Railway had most generously placed every accommodation at the disposal of the British Association. Free passes and every facility were offered that the members could see as much of Canada as time would permit, and naturally they did not appreciate the special attraction of the Yellowstone. The park was just being opened up, and ideas about it were very vague. It was only beginning to appear in guide books, and their information was apt to be inaccurate and misleading.

Briefly, all that was known about it was that it was a tract of land about sixty miles square, on the spurs of the Rocky Mountains in Montana and Wyoming, which Congress had determined to keep in its original state so that future generations might know what America had once been. It was to be stocked (and this has now been done) with specimens of the wild animals of the Rockies, which were even then rapidly nearing extinction.

To anyone who has re-visited the western states since then, the wisdom of this is apparent. Where the railway used to run for days through almost unbroken prairie there are hundreds of miles of cultivated land; and instead of the few clusters of settlers' and miners' shanties there are countless villages and townships; and up-to-date motor cars race the trains on good roads that run parallel to the line.

Beside the fact that the Yellowstone district was a particularly beautiful part of the country, a plateau

about 8000 feet high, with wonderful canyons, tangle forests and high rocky peaks rising overhead, it ha also the unique attraction of being the finest geys basin in the world, and these mysterious boiling foun tains and strange formations made it, at all costs, place to keep as far as possible in its natural stat All this is now familiar to the travelling public and t the student of Baedeker, but in the early eighties th roads were just being made, and though trips wer arranged to go through it there were only two hotels i the course of an excursion that took six days. Th extra nights had to be spent in camp stations whic might be much overcrowded.

These particulars even were not known in Montrea and the party were warned not to attempt the exped tion. The party that started together included Pro fessor Liveing, Dr. Campion, Professor Fitzgerald an the Ramsays. The latter were to meet Mrs. Ramsay brother, Patrick Buchanan, at Livingstone, which th latest available information described as the statio nearest the park. The journey was not like the luxu rious American travelling of to-day. A landslide ha taken place on the C.P.R. line and traffic had tempo arily to go by the Great Lakes and then on by rai as it had always done till a short time before. Th commissariat department was not, however, quite s easily reorganised, and for a day or two meals wer sketchy and peculiar. At one stop in the early mornin breakfast had to be taken at a mining camp about

quarter of a mile from the line, and the next meal was about eleven o'clock at night. Any refection partaken of after six in those parts is, or rather was, called "lunch," and the joy with which the travellers heard the call "lunch served next stop" was somewhat tempered by the nature of the fare, which consisted largely of pumpkin and apple pie in great cold slabs. The older members of the party certainly suffered from the fatigues and hardships of the journey. The younger only laughed and enjoyed the experiences. To Fitzgerald and Ramsay everything was full of interest. They never tired of watching the differences in the wild growths on the prairie, the animals, not yet sophisticated enough to be timid, and later, when they passed through the Bad Lands, "Les mauvaises terres à traverser," the wild and brilliant colours and strange formation that had given them their name. Before starting, a parcel of light literature had been bought, but at the close of the three weeks' journey only one member of the party had read any of them, and she only one.

On arriving at the little town of Livingstone, which had been till a few months before the station for the park, but now was only a junction, the party separated, the elder professors going on, while Fitzgerald and the Ramsays stopped to wait for Buchanan, who had not arrived. As a matter of fact he did not receive their telegram fixing the date of meeting till two days later. Livingstone was in a strange phase of its existence. During the time it was the station for the park, it had

a burst of prosperity, and houses and stores sprang up almost in a night, but when traffic passed on it was as suddenly deserted, and at that time there were only about fifty or sixty people in a town that lately had held two or three thousand. Two days passed with no news. The event of the day was to meet the train that brought passengers from the park and took back those that arrived in the train from the east. On the third day the Ramsays persuaded Fitzgerald to leave them and join some friends who passed through on their way to the park. They had not said so to Fitzgerald, but they were becoming seriously uneasy, and Ramsay had made up his mind to start next day on an eighty miles' ride to the address to which they had telegraphed. However, late that night, greatly to their relief, the wanderer rode into the hotel yard, and anxiety was at an end. Buchanan suggested that if they would trust to his camping knowledge they would have a much more characteristic experience of the wild west than if they were just being taken round with the ordinary parties. As they specially wished to have a quiet time with him they were only too glad, and at once they proceeded to get all necessary camp fittings and stores, and in the afternoon they set off for the real starting place, the Mammoth Springs Hotel. There, to their surprise and joy, Fitzgerald greeted them, "Ye never surely thought I would leave ye in the lurch; I just came here to make sure that Pat was not waiting for us here by mistake." This is not the place to describe

the wonders of the district. The feeling of adventure and absolute freedom were things none of them ever forgot. Every day had its interests and the nights were full of wonders. Once they camped near "Old Faithful." It is the largest of the geysers, and its habits are more regular than any of the others, hence its name. Every 70 minutes it sends up a great rush of boiling water to a height of about 150 feet. Till late that night they sat by their camp fire watching the great column of water go up and burst in the moonlight into glittering spray. And all the night was punctuated by its friendly greetings. Life was simple but busy too. In the morning they were up early, and after hot baths of nature's providing, breakfast was cooked, and the bread for the day baked by half the party while the others saw to the horses and struck the tents, so as to make an early start and take it easy in the hot part of the day. The days were very hot and the nights bitterly cold. The first night, to save time in the morning, the kettle was filled overnight; in the morning it was frozen hard, and much time had to be spent on thawing it, without splitting that valuable possession. The days passed in a sort of wonderland. The great obsidian cliff, with at its base the remains of an Indian arrowhead factory, kept them busy a whole morning, and a day spent at what is known as the paint-pot basin was never forgotten. The paint pots are on the slope of a hill entirely formed of the deposit. It is honey-combed with holes of varying depths and sizes filled

with a paint-like fluid of different colours of wonderful brilliance and purity. It is as if a Titan's hand had set out paints for a gigantic picture. They spent much time over this; Ramsay and Fitzgerald equally keen on identifying the colouring matter and all wondering and excited, finding interest everywhere. They had been warned of the dangers of unfriendly Indians, and that small parties were often "held up." They never saw a redskin all the time in the park, and though one day they felt they were being "shadowed" by two rough-looking individuals, these proved in the end to be two miners whose shyness had kept them back for hours from making the simple request that their photographs might be taken to send back to their friends at home. One night a bear came down and scared the horses away, and it was a long morning's work to find them. Another day there was a thunderstorm, and a tree was struck within a hundred yards of where they had taken shelter in a cave, but youth and high spirits made light of such things, and to them all "the camp in the Yellowstone" was one of the red-letter times of their lives.

Pat Buchanan left them at Livingstone on his way to the district in which he meant to settle, and in 1897 the Ramsays visited him at his ranch there.[1] On the return journey the rest of the camping party were joined by Drs. Foster Morley, Plimpton and Rideal, members of the junior chemical staff at University College, London.

[1] See page 152.

They were afterwards to work with Ramsay when he succeeded Professor Williamson at that institution. At Winnipeg they stepped off to see what remained of old Fort Garry, the great seat of the early days of the Hudson's Bay Company. Twenty years later the British Association was to be royally entertained there, but at that time it was just in its infancy. The houses were mostly one or two-storied buildings, standing back from "side walks" made of rough planking, and the middle of the streets were virgin soil. There had been rainy weather and the traffic had made deep ruts that were nearing danger point, and a great plough was going over them, followed by a thing like a harrow ploughing up the main streets and levelling them down. In a few years all was asphalt and order with electric light and street cars, and old Fort Garry was a thing of the remote past! The next stopping place was Rat Portage, a small station near the Lake of the Woods, which they had been advised to see. They had no very clear idea how to procéed; but while breakfasting they heard a Scottish voice insisting on seeing Professor Ramsay. "A cousin of my own," said the voice, and Ramsay went out to find it belonged to Dr. John Brown, of Burnley, son of old Dr. John Brown, the well-known naturalist of the Cape, of whom he had heard all his life. Dr. and Mrs. Brown had arrived the day before, and had been made welcome by the agent of the Hudson's Bay Company, who had arranged for them a trip in the little steamer that was used to bring in the skins that the

Indians and trappers deposited at different points on the lake, and it was to share in this trip that Dr. Brown brought an invitation. It was gratefully accepted, and though, being purely a pleasure trip, no business was done, it was an experience never to be forgotten. The boat was steered by a half breed. They said no one but a half breed or an Indian could follow the windings of the lake. The islands were so thick that it was more like a tortuous stream than a lake and there never was clear water more than twenty yards ahead. All day they sailed among the islands, the haunts of many different tribes. No living Indians were seen, but they passed many of their burial places, or rather, Isles of the Dead, where in birch-bark hammocks strung from tree to tree, with their tomahawks and water bottles by their side, the braves slept their last sleep among the islands that had once been their undisputed home.

The Browns were on their way to Montreal, and the gradually increasing party went on to Niagara, and unlike some other travellers none of them found it a disappointment. After that came Montreal, science and civilisation. The meeting was a surprisingly large one and very successful in every way.

Ramsay and his wife were the guests of Mr. and Mrs. John Molson, and kindness and hospitality was showered upon them. The most noteworthy events were an excursion to shoot the Lachine Rapids and a *la crosse* match between a Canadian and an Indian team, an entire novelty to the British visitors.

The American Scientific Association had arranged to hold its meeting in Philadelphia immediately after the British meeting was over, and invited members to go. Most of those who had just come out in time for the Montreal meeting naturally wanted to see the western parts, but many of the earlier arrivals went to Philadelphia. The Ramsays were among this number. They were invited to stay with Mr. and Mrs. Lloyd Smith. Mr. Lloyd Smith was a man of vast learning and acquirements, with a great sense of humour, and the Ramsays found the time spent with him and his kind wife more interesting than the meetings of the society. All good things come to an end and duty was calling, so before the end of the meeting the Ramsays took the homeward trail and sailed in the *Polynesian*, or, as it was called, the "Rolling Polly." The voyage was wet and stormy and the *Polly* did not belie her name, so it was a glad sight to see the shores of England once more.

ICELAND, AUGUST 1895

"Ramsay and I spent many holidays together, particularly in the Isle of Arran between 1891 and 1894, late in spring and summer. I forget when we first talked seriously of going to Iceland: we made plans for the summer of 1894, but these had to be changed; it was Arran again that summer. In August 1895 at last we started from Granton for Iceland in the Danish Mail Steamer *Thyra* of the Copenhagen Line D.F.D.S. Ramsay had been working hard and was in want of a rest; he slept a good deal the first day out and was not long in recovering. There was plenty of interest and amusement in the voyage. We saw the Faroes in every possible light, beginning with fog (as usual)

which gave Captain Garde of the *Thyra* some difficulty as we tried for the entrance to Trangisvaag. Then the sea cloud rolled away suddenly; Ramsay and I went ashore at Trangisvaag and up on to the moor behind (among a crowd of whimbrel and oyster catchers) and looked out on a very remarkable view to the north—bright sea between us and the Northern islands—steep rocks (the great and the little Dimun) rising out of the sea with the remains of the fog hanging on to them like flags streaming to leeward.

One of our travelling companions was Albert P. Hanson, a young American electrician from Berlin, who had lived in Iceland and Denmark, and was going back to Iceland to study the telegraph problem. There was no telegraph in Iceland and no cable. Ramsay naturally was interested in Hanson's ideas and conversation, which were not limited to telegraphs. The mist came on again later, leaving blue sky overhead; and as the *Thyra* went slowly on Hanson and his guitar drew the Faroese passengers round him and then we heard a girl singing, very gracefully, the old Faroese ballad of Sigurd the Volsung. And so on through the Northern sounds in fog most of the time—black peaks sometimes showing overhead through breaks in the cloud. We left the Faroes at midnight, under a clear sky—colours of sunset in the North.

Thyra was bound for the east of Iceland, and so north about round the coast. We came in early one morning, so that when we first saw Iceland we were at anchor in one of the eastern fjords. We had come to an important place, where the Icelandic spar comes from. Hanson of course knew all about it and took us—Ramsay and me and D. W. Wheeler, a young Oxford man and one or two others—along the shore a few miles to the spar mine which we found working.

On the way back we made acquaintance with an Icelandic family, by going and begging for milk (much needed) at the house of Sellátrar. Only the children were at home; the eldest

sister, Sigriður Jónsdóttir, was in charge and did the honours of the place most nobly. How much milk was drunk by the strangers I do not know, but there was enough for them. The children looked on and said nothing. I remember the youngest, a solemn water-baby, whose name was Pjetur Tomas. Sigriður was offended at the mention of payment: '*Jeg sel ekki mjolk*,' she said ('I do not sell milk'). She has our thanks, and we went on our way considerably indebted to Iceland.

I remember a midnight at Vopnafjord a little later, and a moon and the sun rising about 1 a.m.,

> "Quhilk to behald was pleasance and half wonder."

as Bishop Gavin Douglas says of the midsummer night in the North. Ramsay spent some of this time visiting a French schooner, where he gave some help to the captain about his letters—I forget how; I was ashore at the time with Wheeler and Hanson, walking up to the moor above the little town. But I remember the white Breton schooner, such as we read about later in *Pêcheurs d'Islande*. Húsavík we saw in a mist: there an American lady came on board, Miss Elizabeth Taylor, beginning an acquaintance which still fortunately continues. So to Akureyri, the great port in the north of Iceland, where Ramsay and I left the ship, meaning to ride to Reykjavík, and Hanson also, meaning to walk, with an eye for a line of telegraph. Mr. Havsteen of Oddeyri helped us with good advice; and the best possible guide, Sigurjón Sumarliðason, found horses for us. We spent some time in Akureyri before starting, and paid a visit, unintroduced and readily welcomed, to the house of Sira Matthias Jochumsson the poet. I was glad to find him at home (in another house) in Akureyri in August 1914; we had met in the meantime in London; our first morning call was not ill-timed, it would appear.

The road we took from Akureyri was the regular way (called *sveitavegur*) with no unusual hazards in it. We were not out for explorations in the wilderness; we travelled in the usual

fashion, and were entertained with the hospitality of Iceland in one house after another.

Of adventures there were few; the whole thing was adventurous enough for travellers who had never been there before and who had to find out for themselves what an Icelandic bridle track was like; who had never before ridden a pony down the side of a basalt slab (it might be lava) or through many rivers.

I remember one evening (at Bólstaðarhlið) when Ramsay found a lot of mushrooms and with difficulty persuaded our hosts to have them cooked for us. I trusted Ramsay in this, but the people of the house took no responsibility and would not eat. They made me think of the islanders watching St. Paul after he had shaken the serpent off: "howbeit they looked when he would have swollen or fallen down suddenly." In our case, however, unlike that of Melita, the failure of the experiment left the original prejudice as strong as ever.

The country we travelled through was not very remarkably different from our own; the valleys were like the glens we know, except that there was a want of granite and mica schist and such-like nobler creatures among the rocks. There were some splendid places, like the Skagafirth country, looking down to the sea; Grettir's island of Drangey showing. It was a great thing to find oneself riding over the moor, which is called Holtbeacon Heath in the story of Burnt Njal; this takes you down to the head of Northwater Dale and so to the passage of Hvamm (or Quam, as it is in the Lanarkshire form of the name), where we spent a pleasant evening talking to Sira Gísli Einarsson, and were sped on the next morning to North Tongue. That day offered a problem to the curious traveller, which even Ramsay was slow in solving. We could not make out the meaning of a number of fires, as they seemed, scattered over a plain that opened before us; little clouds of smoke rising. The truth was, we had got so used to our familiar Iceland, a natural country of hills, glens, uplands, lowlands, and clear rivers—with only

occasionally a strange conical hill, or a distant snowfield, to remind us where we were—that we had forgotten all about the Iceland of the guide books. What we saw and did not understand was the steam of hot springs. We had forgotten all about geysers and volcanoes in that comparatively steady and solid North country which we had been travelling through. We did not recognise a hot spring when we saw it. That same day we rode through a birchwood—one of the pleasures that never grow stale in Iceland.

Our last stage before Reykjavík was from Grund in Skorradal to Thyrill. This—not a long stage—is one of the most beautiful parts of Iceland. It is well depicted by Mr. Collingwood in his *Saga Steads*—both the Skorradal lake with the very finely shaped range of mountains beyond it, and Thyrill, the house under the hill, where we slept that night. We also slept there, outside the house, that afternoon. We got there rather early, and it was bright and warm, and we lay on the grass in the sun and fell asleep. When I awoke, Ramsay was sleeping sound. I did not disturb him, but set out for a walk alone, up to the basalt cliffs above. There is a headland of basalt there, not coming down to the sea, but leaving a good deal of room and the usual grassy slopes below; there the house is built. On each side of this headland there are cliffs, and cliffs of course at the end of it, where we were. There is a gully (among others) cutting into the end of the headland, which is named after Helga in the *Holmverja Saga*—a lady who made her escape with her children away from her husband's enemies, up the rocks. I went to look at this and found it easy enough to get to the top; the tableland was a good place to look out from, and I stayed some time there, and then came down the same way. Ramsay was not there when I got back to our resting-place; and Sigurjón told me he had gone off for a walk. And so the time passed on, and Ramsay did not appear. Sigurjón began to be anxious, and it was late—I think near 10 o'clock—when Ramsay came at

last. He too had made for the cliffs; he took a gully of his own, and must have been coming up when I was going down, or we should have met on the plateau at the top. Then he walked inland along the promontory, looking for another way down, but found everything too difficult till he got a long way inland. I was glad to meet Sigurjón again at Akureyri 19 years later, and to hear him talk of the day when Mr. Ramsay was lost on the hill. Then we came to Reykjavík; I remember the surprise of one of our Eyjafjord horses at first seeing a cart moving on wheels. There are automobiles at Eyjafjord now, though it will probably be some time yet before they have command of the whole way between Akureyri and Reykjavík.

We spent some days in Reykjavík, where we met again our friends from the *Thyra*, Miss Taylor and D. W. Wheeler. They were going home, and Ramsay with them, in the *Laura*; I stayed on to see more, and to take the *Thyra* again on her return voyage west and north about. Before the *Laura* started, we saw the sights of the capital of Iceland; best of all the perpetual view (it was then very fine summer weather) of the white dome of Snaefell, 70 miles away, rising out of the sea—the whole Snaefell peninsula being of course very much hull down at that distance, and the lower mountains east of Snaefell showing like mere islands above the sea-line.

I remember pretty clearly a walk to the hot springs of Reykjavík, a little way from the town. The water of the springs is useful, and most of the Reykjavík washing is done there. Ramsay I think had been neglecting his argon and helium all this time; but the sight of the springs put him in mind of such things. Then began the quest of the bottle among the washerwomen; the bottle was found; and then Ramsay had to fill it with gas from the spring, standing on stepping stones and treated with no great respect by the dames who had to cross the water with their bundles. I was sorry to be told that the bottle gave no results afterwards."

W. P. KER.

Ramsay dated his first letter from the S.S. *Thyra* off Faröe, 3rd August, 1895:

ICELAND

"The ship's company consists of Ker, a bright young American named Hanson, who is head of a manufactory of telegraphic switches and cables at Berlin. He plays a Spanish guitar and sings 'quite a number' of nigger melodies, one 'the golden slippers' well worth hearing. There is a Danish student of law, a nice young fellow. There are several Icelanders, but all speak Danish, and I am getting my ear attuned to that unmelodious language. The American has a Danish wife and speaks the lingo. He picked her up in Iceland about 10 years ago, when he spent a winter there. There is a Brummagem gent of sallow complexion, a man named Howell, author of a *Tour in Iceland*. He is going off to the mountainous volcanic regions in the east to explore further. There is a man of unknown origin and foreign accent, of little speech; evidently a foreigner settled in Scotland. A young schoolmaster who has been ill; and three ladies whom I haven't seen since the day before yesterday. One is an Icelander and wears the cap, if cap it can be called. She is like this [sketch supplied here]. She has been a very beautiful woman, but is no longer quite young. She has come to meet her sister from Winnipeg. The third lady is a Norwegian governess, going to take charge of two little Norwegian girls in the N. of Iceland. I had some talk with her, but she has disappeared for a day as have most of the others. We have had the fiddles on the tables since yesterday morning. The captain is a pleasant young fellow, but at present is not approachable on account of the fog. . . .

9 p.m. We are now lying off Thorshavn, a much larger place,[1] as it appears in the twilight, for it is near 10 and still quite light to see by. The Gudstjienst (guess that) is at 11 to-morrow and

[1] Than Trangisvaag, where they landed. See Prof. Ker's narrative.

Ker and I are going to it. It is in Danish, though the lingo they speak here is Faroese, a sort of hybrid between Danish and Icelandic."

A later letter, bearing no date, begins:

"We have had our first day in Iceland. Yesterday we came through mist and fog all day with the whistle continually sounding. This morning when we woke at 8 o'clock we were on the point of anchoring at Eskifjord on the S.E. coast of Iceland. The hills are craggy and the fjords are not unlike the Norwegian fjords, but more barren looking. The vegetation is scattered along the streams, which run down towards the sea; they are green and there are green patches here and there, but for the most part the land is grey and barren. There are patches of snow low down on the hills, and green spots here and there high up, which I imagine to be green moss. The town consists of a dozen houses or so, like the Norwegian houses of wood, and painted; but there are some turf huts among them—new and old Iceland. We had our usual cup of tea and toasted cookies, and then we landed for a walk of 6 miles to the Iceland spar mines, which we saw from the steamer on the way up. The track runs down the fjord and is like the road up Glen Rosa, only stonier. We met three ponymen on our tramp, and our versatile friend Hanson, the American, had quite a long talk with them. Did I tell you he spent about four months in Iceland, ten years ago? He could speak Icelandic then and remembers some still—perhaps not quite so much as I know of Danish. I find I can follow what they say from its likeness to Norwegian, and I am beginning to get a few sentences together. These men galloped off on their ponies to the village, while we tramped on breakfastless. The mine is more a quarry than a mine. It is thickly crystallised, but in large clear crystals. I have, in spite of strict prohibition, brought several pieces with me; but we saw one piece about 5 in. cube which was absolutely clear, and worth some 800 kroner

=£40. It had been found that morning and had been packed, but the overseer opened his box to show it us. . . . We had a long tramp back and arrived nearly starved at the village, except for a glass of milk (mjolk) from a girl, surrounded by her brothers and sisters, 8 in all, at a little farm hut. The natives aren't pretty, but they are good-humoured looking. I took some samples of rock from the neighbourhood of the mine, lest perchance it might contain helium.

The head man, Karl Gubelius, was introduced to me and made several pretty speeches in Icelandic. To which I did my best to answer in Danish. That is the court language here."

Calling at several places on the way north, the steamer put in to Voporifjord on the north coast, a little town more picturesque than the others. While some of the party went ashore here to attend a wedding, Ramsay had a little adventure of his own. "The captain of one of the French fishing boats came on board wanting if possible to get letters." Here Ramsay was able to help by interpreting for him, and the captain invited him to visit his ship.

"The schooner is, I should think, about 200 tons. The cabin is a wee place lined up with six bunks and rather dirty, and the crew looks savage enough; but they were very polite. I procured a handful of cigars from the steward as a tip and they were very acceptable. We drank each other's health in a deep red liqueur. He tells me that he will have made about £200 by his adventures this summer from March till now and it has not been a very good year. One of the schooners, he says, has made 25,000 fr. They carry provisions and salt in their barrels, and when they are empty they fill them with salt, which is carried in the hold, and salt their fish, which is then packed in the hold. They had a bad storm and had the roof of their

cabin carried away and a life lost. The captain who is a 'charpentier,' repaired it as well as possible, but the roof is not raintight. . . . We saw an interesting sight to-day after dinner; two hawks chasing gulls. The hawks are red-breasted or brown-red and have white tips to their wings. The gulls ducked with a cry and escaped, and the hawks didn't follow up the chase. We watched them wheeling about for nearly an hour.

I haven't seen the Doctor's wife[1] yet; she keeps her cabin. But he is up and about and we drank his health—Skál!—at dinner in a bottle of claret all round. We had a big erection of a cake made up of rings, one on the top of another and a cupid of the female sex on the top of all. This we all ate with great relish, and crackers were pulled by the small remainder of the ship's company. There are left, K. and I, the German from Manchester, the retired apothecary, Mr. Wilkin the schoolmaster, and the candidate for priesthood. There have joined us two Icelanders, one of the hairy red sort and one of the genteel commercial traveller sort. [Sketches of these persons follow.] We are nearer the coast. It is flat and green down to the water's edge—quite low cliffs. We appear to be coming into a new belt of mist, but the sun still shines. I have read *Jane Eyre*, and *Windsor Castle* by Harrison Ainsworth. It is on the model of *The Count*, but somewhat more elaborate. That's about all. Supper calls.

Friday. Last night we started from Husavik, and now, 9 a.m., we are at Ofjord, which is the same as Akureyri. We start on our overland pilgrimage from here, and we have been promised horses and guides to Reykjavík, a distance of about 8 days. . . . The bride has appeared. She is a bright fair-haired girl with a gold tassel to her cap and a lilac silk apron that shows signs of careful folding. That's very like her [sketch]. The dress is rich enough, but not in modern fashion.

This appears to be quite a fashionable place, judging from the number of the people."

[1] This was the newly-married bride from the last stopping-place.

INDIA, 1900-1901

Early in 1900 Ramsay was asked by the Indian Government to go out to India and advise on an educational question of importance. Among the many Parsee philanthropists whose names stand high in the annals of India Jamsetjee N. Tata holds almost the foremost place. He was a man of the widest sympathies and learning, and at the same time of great financial ability and enterprise. His far-reaching intelligence spent itself not only in promoting great engineering and manufacturing projects, but also in striving to improve the education of his Indian fellow-subjects.

In a quiet, unobtrusive manner he had, for many years, helped promising students of the Indian universities and colleges to go to Europe and do post-graduate work in the universities there. This had not always the success for which he hoped, and he felt that an institution in India for post-graduate research of a scientific character, and which would lead to the opening up of careers for its students, would be a benefit to the people at large. To provide such an institution he offered to the Indian Government building land and properties estimated to yield an annual income of £8333, after providing for administrative expenses, rates and taxes and an adequate sinking fund. Further the family of Mr. Tata guaranteed that for ten years the property would yield this income. The capital value of these gifts was about £200,000. It was to advise on the best

way to utilise this munificent gift that Ramsay was asked to go out for the six months of the next "cold weather."

The visit to India to study the problem, and the interesting nature of the proposed scheme, strongly attracted Ramsay, but he felt he could not leave his work for so long, and declined the invitation. The offer was, however, again made for as long a time as he could spare; and ultimately, and with the consent of the University College authorities, it was arranged that after starting the session he should devote a little over three months to the expedition.

At first he hoped that he would have been accompanied by Professor Fitzgerald, as there was an idea that a second expert would be wanted; but that was given up. Ramsay was greatly disappointed at the time, but very thankful afterwards, as it was while they were still away that Fitzgerald was seized with the illness that proved fatal in the early spring. During 1900 Mr. Tata was in London and had many conversations with Ramsay, and in November Ramsay and his wife started to join the P. and O steamer at Marseilles. By leaving London a day earlier than the special train they had a day in Paris, and travelling by the ordinary night train they arrived in Marseilles in the early morning. The town was in a state of great excitement, President Kruger, having succeeded in leaving South Africa, being expected. The Ramsays saw his arrival. In a letter to Dr. Travers the incident is thus described:

"We drove to the landing-stage, where Kruger was to disembark at 10.30, drew up about ten feet from the line the procession was to take and waited. No crowd. People merely stopped to look. The old ruffian had had his face washed and a clean collar on; he has grown a moustache and wore dark spectacles. I snap-shotted him. There was an attempt at an anti-English song, but the two seedy singers were chivied out of the way by gendarmes and fled. The whole crowd could have been packed into the college quadrangle. In the afternoon, however, there was a row, we heard, for about 300 roughs (paid, it was said, by the proprietor of one of the local papers) made a raid on one of the hotels, where some of our fellow-passengers were.

Some of these charged them and found their way down to the boat; but those with ladies were shut up by the landlord and did not reach the *Rome* till about 11 p.m."

The voyage was unlike any of these previously taken, which had been mostly northwards, and everything was new and strange.

Ramsay said that this journey seemed to give him ten extra years of life: certainly it gave richness and colour to it. He was a good sailor and enjoyed every moment of the time. Port Said, the Canal and the strange sights and sounds of the desert delighted him. He never tired of watching the native life. The coaling of the vessel, with the black forms toiling up the gangways in the flaring light of torches, and later the strange processions of Arabs, with their grave and solemn camels pacing along the Canal banks, were pictures that he never forgot. Needless to say, he was not idle on either of the voyages. On the voyage out he worked at Urdu, which he had been told would be the most

useful language to get up. On the return he wrote out his report. He was sorry not to learn something of other languages, but he learnt two or three alphabets so as to be able to read or at least make the sounds of words he saw painted up, *e.g.* names of stations or roads.

By leaving London the day he did Ramsay missed the incoming mail with final *renseignements,* and he had no very clear ideas of how to proceed. Among his fellow-passengers were the Bishop of Bombay and Mrs. MacArthur, and they invited the Ramsays to stay with them if no other arrangements had been made. On arriving at Bombay, however, they found themselves taken in charge by Mr. Padshah, Mr. Tata's private secretary and right hand in all his enterprises, and he took them to Malabar Hill, where they were the guests of Mr. Justice and Mrs. (afterwards Sir Edward and Lady) Candy. While there they had their first experience of Anglo-Indian society. In India hospitality is a fine art. Though Ramsay's end and aim was work, all his time was planned out for him to see as much of the country and its inhabitants as possible, without feeling that he was neglecting the object for which he was sent. If, for example, a long interview with someone was necessary, an excursion would be arranged, and he and the other man would be sent together driving, or boating as the case might be, and so business and pleasure were combined. An excursion to the Caves of Elephanta was the occasion of a long conversation with Mr. Tata on the possible sites for

the Institute. After some days with the Candys the Ramsays went to stay with Mr. and Mrs. (now Sir Dorab and Lady) Tata. He was the eldest son of Mr. Tata, and he and his wife had broken away from the national custom of living in the family abode and had taken a house on Malabar Hill, running it much in the English fashion. Mr. Dorab Tata had spent some years in England, first with a private tutor and then at Cambridge, and Mrs. Tata had been brought up at Bangalore, where her father was minister of education, and she had shared governesses with English girls there. After a dinner party at their house one of the government officials stayed very late and enquired most particularly into Ramsay's plans. What day he would be at Poonah? What day at Bangalore? How many days at Madras? If he had arranged to stay with anyone? At the time Ramsay felt it bordered on the inquisitive, but it was merely a part of the fine art already alluded to. A government "chit" was sent round to every place to be visited, and a request made that everything should be done to further Ramsay's work, and that at the same time every hospitality should be shown to him and his wife. As a result invitations to stay were found all along the route, and English and Indians alike did everything to make the journey interesting and pleasant. In Bombay the most wonderful sight they saw was a Mohammedan wedding, or rather that part of it where the vows are taken. The bride was the daughter of a judge, and a few English

people were invited to this part of the ceremony. It took place in the evening. The avenue was brilliantly lit up with coloured lamps, and the house—a long two-storied front, with marble steps the whole way along—was a blaze of coloured lights. It looked like a palace of jewels. Little boys and girls in gold garments, or so they looked, met the guests on the steps and separated them, the ladies going first to one end of the house to pay their respects to the hostess and the bride, and the men to the great hall where the ceremony took place. Ramsay delighted to recall the look of the room, with its mixture of brilliant colouring and the picturesque figures that might have stepped from the pages of the *Arabian Nights*.

The vows were taken by the bridegroom and his father-in-law representing the bride. They sat together on a couch, and held up their right hands, touching each other but covered by a sacred handkerchief. After this came the signing of the register, in which Ramsay was a witness. Then the English lady guests and a few of the nearest relations proceeded to the large room in the part of the house occupied by the women, with the bridegroom, who with the bride sat on a sofa and formally accepted the presents from their respective relations-"in-law." These were mostly precious stones and heavy gold embroideries and were brought in on trays by servants even more gorgeously attired than the guests. After seeing a few trayfuls presented and bowed over by the newly-married pair, the friends who had brought the

Ramsays took their leave. There was a magnificent supper arranged, but as fingers would take the place of forks it was judged advisable to depart in good time.

The Ramsays were also guests at a Parsee wedding, which was interesting though it lacked the brilliance of colour of the Mohammedan. The ceremonial dress of the male Parsees is white: a short kilt-like skirt reaching to about the knee, and a black hat of a peculiar shape, not unlike a highly polished horse's hoof. This wedding was in the afternoon. A Parsee marriage ought to take place, one half in the house of the bride and the other in that of the bridegroom. As this is often not convenient, a building, or rather a pair of buildings, has been erected in Bombay with a courtyard between them for use at these ceremonies. The first part took place in the building that represented the bride's home. The officiating priest sat at a small table and the young couple sat facing him. On the table was a large book, from which he read steadily in a tongue which almost no one understood. Certainly the couple did not, for they kept up a low-toned conversation with each other all the time. The reader punctuated his reading by flinging little handfuls of rice in their faces, but without interrupting either reading or conversation. After the reading was over, the whole company formed in procession and solemnly walked across the courtyard to the strains of a military band which played "the man who broke the bank at Monte Carlo."

Ramsay was by this time due elsewhere and could not wait for the last part of the ceremony. It may be interesting to add that in Calcutta they were again wedding guests, this time at a Brahma-Somaj marriage, where the service, though in a language they could not follow, appeared not unlike the Anglican form.

The time in Bombay had been very fully occupied, and here a letter of Ramsay to Dr. Travers, dated 11th December, may be quoted:

"We are in India! The exclamation mark is to express the absolute petrifaction and astonishment we both have at every thing we see and smell. It is simply overwhelming. People of all colours, from nigger black to pure white; dressed in all sorts of clothes, from none at all save smiles and a nose ring to the most elaborate turbans, white overalls, and jewels of rare lustre, through all shades of white, yellow, orange, greens, blues, lilacs and purples. No browns or sad colours. It is a spectacle that would make a colour-blind man curse his misfortune. The oddest groups: a woman with a naked child straddling her sideways, a scuddy (if you don't know what that is, ask Donnan) of the male persuasion holding her hand, talking to an old gentleman of the Mr. Swan type, with spectacles and a white turban with a scarlet thread twisted in it, and bare legs, sitting on his hams writing a letter for the lady. Two chaps with 'nozzings' on except a waist cloth and even exceptionally naked heads, caused by an early and persistent use of the razor;—that's the kind of group that meets you everywhere. Old, old women, wrinkled and white-haired, with the remains of good looks about them, with the usual scanty garments, a saree, or gauzy shawl, and a short petticoat. Fat, prosperous-looking oily Hindoos, with white turbans and white blouses and trousers; Parsees with black bishop's mitres and European dress; in fact, one

might go on for a week describing and not exhaust one-tenth of the oddities that one sees every moment. The crowds are prodigious, they swarm and struggle for space to stand or sit on. I am getting fluent in 'ghar ko jaloo,' etc. The most familiar part of Hindostani is the imperative mood, and indeed many Anglo-Indians never get beyond it. We have also a Goanese sprite, who goes and comes at our bidding. He is supposed to know English, and readily understands what one wants, but his replies are often enigmas. However, with 'nods and becks and wreathed smiles' we get along pretty well. You will wonder where education comes in here. Well, I have had long talks with Mr. Justice Candy, the Vice-Chancellor of the Bombay University, and with Mr. Giles, the Director of Public Instruction. I have seen a reasonably good technical laboratory run by as a private spec. He evidently has a lot of go about him. I have seen the Wilson College, where a sort of junior arts and science course is given. They, too, are dependent on the Bombay University, an examining body, with affiliated colleges after the fashion of London University in 1859, when they were founded. I had to give a short account of what I intended to do. That is to go to Poonah on Sunday afternoon, spend Monday there; start on Monday night for Bangalore and arrive in 36 hours; thence to Madras, where we spend some days; thence to Calcutta by sea (Xmas on the ocean) and stay over the new year at Calcutta. Then up the Ganges valley to Benares, etc., as far as Lahore I think, and then back to Bombay by Allahabad. Padshah, the secretary, will not come with us. I want to see things with my own eyes, and not through his spectacles; he is theosophist, vegetarian, altruistic, and an admirable Crichton after the Indian model. We are going to see the Towers of Silence on Thursday. On Saturday we are to see the Caves of Elephanta and also Jain temples. But the streets are the real attraction. We spent a couple of hours this morning wandering through the markets."

This programme was pretty well carried out, but it might be permitted to say here a word or two of the Goanese travelling servant who piloted the travellers on their long and rapid journey. He was selected by Mr. Tata, and having mostly travelled as part of a large suite, he was a little pained to find himself single handed. However, after a few days to readjust his ideas, he became the most devoted retainer, regarding Ramsay as a personage who must never be troubled with any details as to trains and conveyances till the moment came to use them. His "chits" (testimonials) spoke of him as a perfect servant, *shikari*, sick nurse and, if necessary, medical adviser, and he did not belie them.

Towards the end of the time when the constant travelling had begun to tell and Mrs. Ramsay had some days' illness, he treated her with great skill and severity. All food sent to her room by an attentive hostess was most gratefully accepted and as promptly burnt, and only slops of his own providing were given to the invalid. The hostess found it out and was much amused, but the results were most satisfactory. When she was restored to ordinary life his vigilance did not relax. In Bombay the servant goes out with his people, and at a dinner party there a fellow guest said to Mrs. Ramsay: "Does your man ever allow you to eat anything? for I notice that whenever you help yourself to anything he takes away your plate before you can touch it." He was most scrupulously honest towards

his employers, but not so much so as regarded their interests. If they admired anything in their room, it appeared in the next house they stayed at, and on one occasion an entire set of toilet bottles that had been on the dressing-table of the room in a friend's house, where they had dressed and dined, appeared on their table next morning. As he had a walk of over six miles to restore them, he learned to curb his enthusiasm to a certain extent, but books that he thought "his lady" was reading he purloined till the last.

The travelling was almost incessant, and not particularly pleasant just at that point. To save time, they went mostly by night, and as they were coming from a plague-infected area, at the boundary of every state they entered official doctors came on the trains and felt pulses and generally disturbed the travelling public. Poonah and Bangalore were both possible sites, and had to be seen. The latter was finally selected. Then came Madras, where there were more colleges and institutions to be visited, and people to be interviewed. There they stayed with Mr. and Mrs. (now Sir John and Lady) Atkinson, connections by marriage of Ramsay's, and they did all they could, not only to help him in his work but to make the time in Madras a very happy one. A few days before their arrival the new railway to Calcutta had been opened, and as going by it would save a day or two the idea of the sea voyage was given up, and on Christmas Eve they started on their journey northwards. It was a very odd Christmas Day

The railway was so very new (it had not been opened a week) that things were always going wrong, and long stops were frequent, often in lonely places. This was interesting, for they saw something of the wild life of the jungle, though the hoped-for tigers never appeared. The train being hours behind time, the Christmas dinner would have been altogether missing but for the foresight of the faithful Fonseca, who, distrusting new railways and their commissariat arrangements, had provided stores which he cooked in ways known only to himself. A lean little chicken served as turkey and was followed by a plum pudding, begged from Mrs. Atkinson; so all was well.

In Calcutta the Ramsays stayed with their cousins and intimate friends Mr. and Mrs. Nowell Watkins. After such constant travelling, to settle down for ten days or so in such sympathetic surroundings was a great rest. They came in for the height of the Calcutta winter season. Everything centres round Government House and they lunched and dined there and attended a Drawing-room, one of the most brilliant sights they saw. Lord Curzon was Viceroy at that time, and he and his lovely wife did everything to give splendour and dignity to the great position.

The days were filled with work, meetings with heads of departments, where the Tata scheme, in all its bearings, was discussed. There were colleges and schools to visit, so the time passed very quickly away. There was one lovely morning on a yacht on the Hooghly, and Ramsay

even went to the Baligunj races, where as usual his chief interest was in the native crowd. They would have liked to attend the state ball, but the stay in Calcutta had been longer than they had intended and they left that night for Patna. Ramsay found two of his old students on the staff of the college, and they brought their wives and babies to exhibit them to him and Mrs. Ramsay. The call was somewhat difficult, as the ladies only spoke Urdu, and it bade fair to be a lengthy one, as the Ramsays had not yet learned to use the formula "It is now permitted to depart." The visitors would not have felt justified in going without it, but fortunately a baby cried, and a remark that probably he wanted to be taken home seemed to give the required suggestion, and the call ended satisfactorily to all concerned.

Allahabad was the next stop, and there they were the guests of Mr. Fred Balfour, a very dear young friend, now alas dead! Their visit fell at a very interesting time. In January a great "mela" (religious festival) is held there where the Jumna joins the Ganges, and tens of thousands of devout Hindus gather and settle for some weeks on the wedge of low-lying land between the two rivers. The Civil Service has to see to arrangements for sanitation and for keeping order in the vast multitude, and the Ramsays spent some time in the temporary Government office watching the strange spectacle.

There were fakirs lying on boards covered with nails, point uppermost, others with their arms held up till

they had withered, venders of images, preaching fakirs, and round them all the great surging, tightly massed crowd with a constant hum of voices night and day—and all this under the control of a handful of young men mostly in their early twenties. The responsibility for the health and orderliness of these multitudes was in their hands, and how ably and tactfully these boys face similar problems only those who have been in India can know. At Benares the great educational centre was the new college founded by Mrs. Besant for the sons of the wealthier and stricter Hindus. Ramsay had a special interest in visiting it, as an old assistant of his, Dr. Arthur Richardson, who had a few years previously embraced theosophy and was in sympathy with Mrs. Besant's views, was Principal and Professor of Chemistry in the college. Ramsay gave a short lecture the day he spent there and, of course, saw the laboratories.

Cawnpore and Lucknow were next visited, but as neither were thought of as sites for the new Institute, and there was not a great deal in either with a bearing on the work in hand, the visits were very hurried. There was time, however, to see the memorial over the well, and the ghaut of tragic interest at Cawnpore and at Lucknow, that monument to British courage and endurance, the ruined Residency, with its flagpost on which the flag is always flying, and the graveyard where so many of the best and bravest of its defenders lie. Wherever Ramsay had been he had been told "the man whom you must see is Hankin of Agra," and it was with much interest

they found they were to be his guests during their stay there. His real home was in the club, but when he had visitors he moved into the Ram Bagh, one of the old Moghul palaces, now used as an official bungalow for entertaining. It stands on the high bank overlooking the Jumna and has been little changed in the passing of the centuries. It is built wholly of white stone inside and out, and the ceilings of the rooms are dome-shaped, but the interiors of the domes are broken up into outstanding geometrical figures, so that it was, as Ramsay used to describe it, like living inside a large pudding mould. At Agra there was much to see bearing on Ramsay's mission, but there was also much to talk over, which could be done while visiting the points of interest in and near the town, such as the Fort, with the lovely Jasmine Tower, and the world-famed Taj Mahal. Of all he saw in India nothing struck Ramsay so much as the deserted town of Fatipur Sicri, which was built, lived in and abandoned all in the space of about forty years, in the reign of Akbar. It is built of red sandstone, on a hilltop about twenty miles from Agra, and untouched by time it stands just as it did in the days of the Great Mogul. After Agra came a visit to Roorkee to see the engineering college there. The head of it was Colonel Clibborn, R.E., and he and Mrs. Clibborn did everything to make the visit happy, but a great shadow lay over the world at that time, for it was the night before they left that the news came that Queen Victoria, "The Great White Queen," was no more.

From that time there was a cloud over everything. It was a time of real heartfelt sorrow. The bright turbans disappeared and pathetic little bits of black were tacked on somehow to the garments of even the poorest.

Lahore was the next place on the programme, but as the Lieutenant-Governor was in camp and as Ramsay specially wanted to consult him on the subject of Bangalore, where he, Sir Mackworth Young, had at one time been resident, Lahore was given up and a visit to the camp on the other side of the Sutlej was arranged. Two days were first spent at Delhi, where they had time to see the Ridge and the various spots so well known in the history of the great siege, which they did in the company of one of the people Ramsay had specially to consult, so no time was lost. The journey to the camp was rather a novel experience. The first part was by train and thence across country to the Sutlej. The ruler of the native state had been asked to convey the travellers from the railway to the other side of the river and to do this had made in four days a road about eleven miles long and laid it with rushes to keep down the dust. Along this the Ramsays were driven in a state carriage drawn by four mules, objects of much interest to the inhabitants of the villages along the route, who had watched the road being made and were curious as to its object. From the carriage the travellers were put in palkis, in which they were carried on board the boat in which they were taken across the river, and on the other side they were received by some of the staff and

escorted to camp. An official camp is a wonderful organisation. It consists of a double supply of tents, camels, wagons, etc., so that when one camp station is left there is another fully equipped to arrive at; and the one just left is rapidly dismantled and conveyed to the stopping place next again on the route.

The camp is a village in itself, containing government office tents (even a post office), accommodation for the staff, the residence of the Lieutenant-Governor, with great state reception rooms and quarters for guests. These visitors' tents contain sitting-rooms as well as dressing-rooms and bed-rooms, and are fully furnished, though naturally the furniture is of the light kind. The whole thing is on a scale difficult to imagine. Something like seven hundred camels were employed to remove the camps from place to place. Two nights were spent in camp, and Ramsay had a morning's duck-shooting, to the scene of which he went on a camel. There were also strange little desert villages to be visited, so that a few days' stay would have been a most welcome rest and a great pleasure. Time, however, would not stand still, and with much regret they took leave of their kind hosts, were driven once again along the new road, and took the train back to Delhi, whence they started on their return journey. By this time Ramsay had made up his mind to advise that Bangalore should be the site for the Institute, and he felt that he should get back to Bombay as quickly as possible to go into details connected with the future organisation

and possibly to revisit Bangalore. The one stop they made was at Baroda, where they stayed at the Gaekwar's guest house, and next day Ramsay had a long interview with him and his minister of education, but he had not time to see the treasures, even of the town palace, or anything of the city itself. Fortunately a second visit to Bangalore was not required, so the remaining week was spent in consultations with Mr. Tata and his advisers and with the University authorities, which furnished Ramsay with ample material for his report. Looking back on the time they spent in India, Ramsay used to say it was like reading the index of a book, with no time to read the book itself, and he wondered if he might ever see it again without the constant need to "move on." It was not to be, but the glowing memories and the friendships formed and consolidated there coloured all his after-life.

On the voyage home Ramsay wrote his report and also a long letter to his friend Fitzgerald, who had so nearly been his companion on the journey. In this he put more briefly what he thought should be done. The letter was returned unopened, having reached Dublin after Fitzgerald had passed away. Portions of the letter may be quoted here:

INDIA

"P. & O. Steam Navigation Co.,
S.S. Caledonia, 19. II. 01.

Let me give you a brief sketch of what we saw and what I have recommended. First we spent a week at Bombay; th

went to Poona, Bangalore, Madras, Calcutta, Patna, Benares, Allahabad, Cawnpore, Roorkee, Lucknow, Agra, Delhi; visited Sir M. Young at his camp near the Indus, at Sidpur, back to Delhi, then to Baroda, and finally back to Bombay. The site I have fixed on is Bangalore. The climate is excellent, neither too cold nor too warm. It is 4500 feet up, and there is a sort of fresh feeling like that on the top of a hill. There is a geological station there, an agricultural station, a college, such as exist in India. More about them hereafter. They offer a splendid site, 300 acres in extent, in the best part of the town, which is very open. They have £1200 a year to play with, a sum which has fallen to the Mysore State as the result of a disputed legacy, and which they wish to spend for the good of the state. The revenues of Mysore show a huge surplus which can't be annexed by the Maharaja, for he has a private allowance of £150,000; also the Cauvery Falls, 40 miles from Bangalore, are being connected with the Kolar goldfields, 45 miles in the other direction, and the leads pass within 7 miles of Bangalore. They are going to begin with 4000 H.P., but measurements show that for 8 months of the year 100,000 could be got. Lastly, there are endless deposits of iron ore, manganese, magnesia, etc., near, all of which might be exploited. So I have recommended Bangalore. . . . The Committee have asked me to nominate the first members of staff and I have suggested names.

They will have to get out a lot of young fellows of a technical kind from home, as many as they can afford. . . .

The students will be selected by the heads of Colleges, at the rate of about 15 a year. They must be men who show intelligence and grit. More will be sent than can be permanently kept; they will all get three months' trial. These fellows will almost all require 1 to 1½ years chemical and physical work before they are much good. There is hardly any laboratory work done in India. . . .

Next these members of staff must each take up some question

of the development of some industry, and the utilisation of some natural product; each will associate with him some students as assistants, and they will develop the processes as far as laboratory work can do it. There is the £1200 a year to draw on for large-scale experiments. I suggest that small works should be put up, so as to get beyond the laboratory stage. And, lastly, the Mysore government out of its surplus should provide half the capital, on terms. . . .

There are really no industries in India; any amount of raw material, easily got and cheaply worked; and there is no opening for any young men scientifically trained, unless openings are made. The colleges are wretched places as a rule, though here and there exceptions must be made, and the whole system is rigidly examinational like the L.U. They are reaping the fruits of it in a number of cramming shops, miscalled colleges. . . .

I can't in a letter tell you all about our tour. It was the most interesting experience from first to last that I have ever had, and we met all the most interesting people from the Viceroy to the coolie. I can speak enough Hindostan to get on . . . and really to understand the drift of the answers made.

Now adieu, and affectionate regards from both of us to both of you.—Ever yours, W. Ramsay."

FINLAND, 1907.

When Ramsay arrived in a foreign country the first thing he did was to buy some books in its language in order, as he would have expressed it, to rub it up. When in Sweden to receive the Nobel Prize, the book that interested him most was one called *From Golden Locks to Silver Hair*, by a certain Andreas Ramsay of Finland. It was partly an autobiography and partly a family history, and dealt with the stories of many of the Swedish

families which had migrated to Finland in the sixteenth century. The name of the author interested him at once and also the fact that so many of the Swedish settlers in Finland bore other Scottish names. After reading it Ramsay wrote to the author saying how much he had enjoyed the book and asking him if he were any relation of a certain Professor Wilhelm Ramsay, who often had papers on chemical and geological subjects in German scientific publications, and whose proofs had sometimes been sent to Ramsay by mistake. Andreas Ramsay replied at once saying, that Wilhelm was his nephew, and asking many questions on his part as to the Ramsay families in Scotland. From that time a lively correspondence ensued. Ramsay had always hoped to visit Finland, but it was not till 1907 that a favourable opportunity occurred. That year, as he could not get the house he wanted for the summer holiday till September, and in the beginning of August was tired out with a busy session, he thought that a voyage to Finland and a week there would provide a good change and a rest from correspondence. It was quickly arranged, and he wrote to Mr. Ramsay saying that he expected to be in Helsingfors in the middle of August and hoped to call on the old man while there. Ramsay and his wife started on the 10th going first to Gothenburg and across Sweden by the Gothenburg canal. That part of the journey interested Ramsay very much. The enormous height to which the canal had to be carried represented an engineering feat which

he fully appreciated, while the pleasantness of th canal voyage, part of the time spent in walking fro lock to lock, was exactly the kind of rest he neede On reaching Stockholm he was surprised to receive once a visitor on whose card was the name "Ramsay This proved to be a member of the Swedish branch the family commissioned by Andreas Ramsay to p himself in touch with the shipping lines and keep hi informed of the London Ramsay's plans. A first-cla criminal could not have been more adequately dea with. Mr. Ramsay evidently forwarded all the info mation he got by telegram or telephone, for on arrivi at Åbo, the first port of call in Finland, whence the were to travel by train to Helsingfors, there was standi on the landing-stage a fine-looking old man who w eagerly scanning the faces of the arriving travellers they descended the gangway. When Ramsay passe down, he evidently recognised him at once, and witho a moment's hesitation the old man threw his arms rou him, and murmuring "Mon cher cousin," welcomed hi to Finnish soil.

From that time forward the plan of seeing somethi of Finland resolved itself into seeing very little exce Helsingfors and its immediate surroundings, but a gre deal of the Finlanders, especially of the Ramsay famil and learning something of the history and gene conditions of that sorely tried little country. Like mo of his countrymen Ramsay had always referred natives of Finland as Finns or Finnish, and the fi

thing he had to grasp was that there are Finlanders and Finns, and that the two races are absolutely distinct. The native race of Finns have a language and a type, slightly Mongolian, of their own. The Finlanders are of Swedish descent, and are largely mixed with Scottish families who migrated to Sweden in the time of Gustavus Adolphus. Intermarriage between Finns and Finlanders is very rare. Doubtless when Sweden lost Finland in the early days of last century, many patriotic Swedes returned to Sweden. The Scots, however, cared more for their homes than for the question whether Sweden or Russia were to be their sovereign state. They therefore remained and carried on the traditions of earlier times.

The morning of their arrival the Ramsay trio went sight-seeing in Åbo and stayed the night there, starting early next morning for Helsingfors, where they were allowed to go to the hotel. Their rooms had been already engaged, but except to sleep and have early breakfast, they were hardly ever in it. Mr. Auguste Ramsay, a nephew of their original friend, prepared a programme for the disposal of their time, and nothing could have been more interesting. Helsingfors lies in a deep bay with the island of Sweaborg in the middle of it. Beyond it on the east and west are scores of small wooded islands on which most of the Helsingfors families have country houses, to which they remove for the summer. Being August the various Ramsays were in their summer quarters, and

the days were mostly filled up with visits to one or other of these islands and making acquaintance of the various branches of the family. Sweaborg, an island fortress, is or was the headquarters of the Russian army in Finland, and more closely guarded from civilian intrusion than our arsenals and naval dockyards. Any boat going within about a quarter of a mile of the shores was warned off by a gun, and had it persisted would have been fired upon. The summer before there had been a mutiny among the troops, and the numbers being nearly equal warships had to be called in before it was quelled. So near is it to Helsingfors that the groans of the wounded and dying could be distinctly heard, and the cannon balls that overshot their mark lodged among the homes in the islands. "C'etait bien désagréable, il m'a fallu me remuer chez mon fils," as one old lady put the fact that her house had been struck and her garden devastated by these shots, in much the tone she would have used in speaking of a specially heavy shower of rain. It was rather a polyglot existence. Ramsay knew enough Swedish for all travelling necessities, but among their friends French, German or English was spoken. The older people all spoke French, but some of the middle-aged were more familiar with German. The younger generation were all learning English in preference to German, and were delighted to have an occasion to speak it. A year or so before their government had made Finnish a compulsory language in schools, and as the list already

included Swedish, French and either German or English, the youth of Finland had their work cut out for them so far as modern languages were concerned. The first day at Helsingfors was spent with Baron and Baroness Ramsay at their home, Monksnaes, about five miles from the town. The baroness was English by birth, though her life had been spent entirely in Russia and Finland, and she greatly enjoyed talks in her native tongue, though when her husband was present French was always used. This visit was repeated several times, and there the Ramsays met the children and grandchildren of their hosts, who were all equally kind and ready to welcome their "cousins" from overseas. Baron Ramsay, the head of the Ramsay family, was a striking-looking man, an unmistakable soldier and a figure in history. He was Commander-in-Chief of the Finnish army till about three years before, when, without a word of warning, orders came from Russia that the entire army was to be disbanded at once. Some weeks before this the rifles had been called in on some slight pretext, so resistance, even if thought of, was impossible. It was a heavy blow. The army and its efficiency had been the chief aim of General Ramsay's life and he felt it sorely, but with wonderful pluck and determination he and the other officers set themselves to confront new conditions, and, by establishing new industries and developing old ones, to find employment for the soldiers now thrown on their own resources. Russia's idea had been that the soldiers would now join Russian regiments,

but the feeling against it was so strong that the idea had to be abandoned, and instead of the soldiers being enrolled in the armies of the Czar, a large indemnity, payable over three years, had to be guaranteed. In 1907 two of these annual payments had been made and the third was nearly due. In the meantime, however, a change, not only of government, but of the entire constitution, had taken place, and there was a strong feeling that the new parliament might repudiate the previous agreement and refuse the third payment. In this case Helsingfors would be bombarded by Sweaborg. The Ramsays were in Finland in the latter part of August and parliament was to meet early in September, but though matters were so critical that a pretext had been made to delay the opening of the schools till after the debate on the question, nothing was made of the seriousness of the matter so that the visit should not be clouded by the overhanging possible tragedy. In those days of peace, the thought of the bombardment of the town they were living in and the sight of the damage done the previous year at the time of the Sweaborg mutiny, seemed to the Ramsays like stepping into the midst of "old, unhappy, far-off things" of bygone centuries. Now, alas, such things are no longer strange and wonderful!

Only one night was spent away from Helsingfors. This was at Tammerfors, an industrial centre where Mr. Walter Ramsay had his home. Andreas and some of the younger members of the family and, for part of

the way, the Deputy-Governor, were of the party. The latter was the only Russian the Ramsays met during their stay. Halfway the journey was broken to see an intimate friend of the family, whose bad health prevented him going to the capital to make the acquaintance of the visitors. He was a large land-owner and of great wealth. Ramsay said that the preparations for their reception reminded him of the old story of "Bring more curricles," for about seven or eight carriages were in waiting at the station, so that everyone should have a choice as to which kind of vehicle he or she preferred. In going through the coach-houses and stables later in the day the Ramsays saw that these were only a very small proportion of the number there. The house was large and roomy, but adjoining it was a guest-house, with many bedrooms, where visitors generally stayed so as to have no fear of disturbing their invalid host if their hours and his did not correspond. All these rooms were ready, but it was not possible to prolong the visit beyond the late afternoon. Their host had done a great deal in developing the resources of the district and Ramsay saw there something of the difficulties and possibilities of food production in these northern regions. It was night when they reached Tammerfors, and to Ramsay's great surprise he found that Swedish was now of no use, as all the porters, cab-drivers, and most of the shopkeepers spoke only Finnish. What he thought even more remarkable was that Anders Ramsay did not know

even the coins and numerals, and the cab fares had to be settled by holding out a handful of money and leaving it to the cab-driver to choose.

By next morning Ramsay had learned enough Finnish to tackle such questions and also to make a few pleasant remarks, though the answers for the most part were beyond him. The day in Tammerfors was spent in visiting woodyards and paper-mills connected with the great industries of Finland, and also the new church, the latest thing in Scandinavian architecture and decoration. In the afternoon the party, largely augmented by more members of the connection, went a steamer excursion on the lake. This was the only one of the chain of inland lakes the Ramsays saw, and the trip had to be a short one as they were to return to Helsingfors that night.

The other days of the stay were spent in yachting and visiting the homes on the islands. Mr. Auguste Ramsay, who had planned everything, was kindness itself, and the Ramsays spent much time with him and his family. There they met Professor Wilhelm Ramsay, whose name had been the medium of introduction between the two branches. They also spent a day with old Mrs. Ramsay, his mother, a woman of exceptional charm and with the remains of great beauty. It was she who had found cannon balls striking her house "really disagreeable." It was at her house that the Ramsays met General Schaumann and his wife, one of her daughters. He was a sad-faced man, much

broken in health by many months in the prison of St Peter and St Paul. He had been in command of troops in an outlying part of Russia and was suddenly arrested and thrown into prison with no reason assigned, and for nearly a year knew nothing of the charge against him or what was happening to his family. Many readers will remember the assassination of the Russian governor Bobrikoff in 1905. On his appointment Bobrikoff had declared that if he were allowed a free hand he would reduce Finland to subjection in two years. This was granted and a time of unexampled harshness and severity began. Then when some specially hard measure was about to be taken, a young civil servant, when he brought in some papers to be signed brought also a revolver and killed the tyrant and with the next shot ended his own life. This was the brilliant and idolised son of General Schaumann. At once all the intimate friends of the boy, he was little more, fell under suspicion, their houses were searched for incriminating documents, and the father was arrested and imprisoned. The search, however, revealed no trace of any complicity. Evidently the boy had made up his mind, and without a word to his most intimate friends, did the deed. His sacrifice was not without avail. A milder governor was appointed, and the country had a time of peace and gentler rule. Young Schaumann was spoken of as "Ce jeune héros qui a sauvé le Finlande."

On the morning of the 25th August the Ramsays left Helsingfors, seen off by seventeen of their name and

many others of the connection. Mrs. Ramsay, Anders and the Baron and Baroness Ramsay they never saw again, but many of the younger members of that happy party came to England and found a welcome at Chester Terrace during the next half dozen years.

They returned to Stockholm and thence went by railway across Sweden, finishing their holiday with a few days spent with Ramsay's friend, Professor Otto Pettersen, at his country home near Barstrand. He has a large experimental farm, and on an island opposite the house is the Government laboratory of Marine Biology, of which he is the head. It was a very happy time, the family were nearly all at home, among them the son Hans, who afterwards came to London to University College, and whose work on the micro-balance is now well known.

Many friends have said that Ramsay was a perfect host, but he was an equally good guest. Whatever the nationality or status of his hosts he at once identified himself with their interests, and young people always accepted him as one of themselves. It was so at Halma. Neither he nor the young Pettersens ever forgot those few days together. An excursion was made inland to see the curious rock carvings attributed to the bronze age, and farming problems were studied, but the great interest was the laboratory on the island. Its fascinations might have had serious results. Professor Pettersen was going to Gothenberg that week and it was arranged that the Ramsays and some of the

young people should go with him on the official vessel, breaking the journey at a little island on the way up a fjord in the Cattegat that was the original home of the Pettersen family. On the morning of departure the two professors went over to the laboratory for an hour, which was so much prolonged that the start, which should have been about eleven, was not made till the afternoon, and it was nightfall before the mouth of the fjord was reached. It was now impossible to take the little gunboat through the labyrinth of small islands, so an anchorage had to be found and a boat launched. There was still a row of more than a mile, and with the darkness, a rising wind and sheets of rain, it was rather an adventurous voyage. At first the sailors steered by the chart, but after one or two narrow escapes of running on the rocks, Hans Pettersen took the helm and, as he evidently knew the currents and channels blindfold, he brought the boat safely in at last, and it was a much relieved and happy party that scrambled up the steep and slippery rocks to the hospitable door of Cauliflower. Cauliflower, needless to say, was not the right name of the island, but a phonetic rendering that Professor Pettersen always used for his English friends. This was the last night that Ramsay spent on Swedish soil, as the steamer left Gothenberg for England next day. It was not, however, the last time he saw the Pettersens, as they came to England in 1911 and stayed with the Ramsays on the Thames before the meeting of the British Association at Portsmouth.

AMERICA IN 1912.

This last visit to America differed in many ways from previous visits, and was perhaps the one Ramsay enjoyed the most. All the previous journeys were made at lightning speed, everything having to be done in a very limited time.

As retiring President, Ramsay had arranged to attend the triennial meeting of the International Chemical Congress at New York in September of this year, and he obtained leave of absence from University College for a great part of the autumn term. He had, therefore, nearly four months at his disposal, and determined to spend the time in seeing parts of America that he had never seen before. This was made the more easy by the fact that he had been asked to be one of the lecturers at the opening of the Rice Institute in Texas in October, and to deliver a course of the Lowell Lectures in Boston at the end of that month and the beginning of November. These engagements all fitted in, giving intervals of leisure, so that there was plenty of diversified interest and yet no feeling of hurry, while the fees for the lectures removed all difficulties in the way of a very enjoyable holiday.

On the 9th of August the Ramsays started from Liverpool on the *Tunisian*. Previous voyages had been timed to suit meetings of the British Association, 1884 and 1897, and the Society of Chemical Industry in 1904, and on these occasions the ship had been full of colleagues

and friends with the same interests, so that there was a constant tendency to talk "shop," and that, however interesting, was not relaxation. This time there was no one on the boat of specially scientific tastes and very few people they had known before.

There were, however, Lady Ramsay's old friend, Mrs. John Tennant, and her husband, and Sir Henry Craik, also an old friend, and his travelling companion, Canon Perkin, of Westminster. The six had a table together and made a little party by themselves. The very fact that their interests were all so diverse made the time pass most pleasantly, as well as more restfully than on any previous voyage. The only incident of special note was a stoppage in fog off the coast of Newfoundland. The *Tunisian* had made almost a record run, but a wireless message reached it that icebergs were ahead and had struck another ship, and as the fog was very dense there was nothing for it but to wait till it cleared. Two days passed—with no sound but the fog-horn, and even the sea not visible from the upper deck, so dense was the fog. The ship might have been imbedded in cotton wool, and there seemed to be no reason why the fog should ever lift. One of these days was devoted to the usual sports, and a joker among the young passengers put up a notice, "Athletic Sports will be held every Thursday till further notice." However, on the Friday morning there was a welcome sound of revolving screws, and on the morning of the 19th the party reached Montreal and went their several ways.

Thursday had been spent by the Ramsays in driving about Quebec and the neighbourhood under the guidance of a very loquacious driver, who was much more interested in pointing out a window from which he had seen Crippen look out the week before than anything on the Plains of Abraham.

The first part of the time was to be spent with Dr. and Mrs. Nichols at their country house on one of the Thousand Islands in the St. Lawrence. Dr. Nichols was already a great friend of Ramsay's, and was to be President of the Congress. On arriving at Montreal a friend of Dr. Nichols met the steamer, rushed the Ramsays and their baggage through the Custom House and put them in the train for the next stage of the journey. At the station to which they had, so to speak, been consigned (Gananaque), they were met by Dr. Nichols, Mrs. Nichols and other members of their family in one of their yachts, which in an hour or two brought them to "Nokomis."

Like the islands round Helsingfors, in Finland, each of the Thousand Islands has one or more summer homes built on it, and these vary from the palatial dwellings of American or Canadian millionaires to tiny structures built on slabs of naked rock, but all with boat-house, boat or boats and landing-stage. The Nichols' invitation had been worded "to stay at our little camp on the St. Lawrence," but "camp" is a word of wide interpretation. If being built of wood made it a camp, then camp it was, but a very lovely picturesque house

would be a more definite description. Its cream-coloured walls, red roofs and turrets might have looked over a smiling Surrey landscape, and it is sad to think that lovely house is no more, for the following year it was burnt down. Another house has been built, but the old "Nokomis" is gone. The time spent there was just the kind of holiday Ramsay loved to take in Scotland, in a house by the sea (in this case it was on the river), boating and bathing, with room enough for a friend or two to share the pleasure. Only the scale differed: in Scotland a small motor launch and a rowing boat met his wants, but at "Nokomis" there were two, if not three yachts of different sizes, several launches and quite a fleet of smaller boats. The pleasure, however, was the same. The island was a large one, and had actually a riding track about a mile long.

The bathing was most luxurious. The bathers came from their rooms, crossed half-a-dozen yards of lawn and stepped into the St. Lawrence, which, being wide just there, had not a very strong current. There were excursions to visit friends on other islands, one to Kingston to see an old assistant of Ramsay's, a regatta, mornings of tennis and afternoons of fishing, evenings of games and talk, so the time went past all too quickly.

As some arrangements for the Congress were yet to be made, the whole party decamped on the 30th to New York, where they took up their abode at the Belmont Hotel. Dr. Nichols' own home was in Brooklyn,

but for the purposes of the meeting he thought it necessary to be in New York itself, and as he had invited all the previous presidents who were attending the meeting to be his guests, there was a large party. The meeting was to have been opened by President Taft, but unfortunately he had an accident or illness and his doctors forbade him to travel to New York. With truly American promptitude and resource, the arrangements were changed, and reversing the Mahommedan tradition, as Mr. Taft could not come to the Congress, the mountain—that is to say the Congress—went to him.

All had to be settled very quickly, special trains arranged for, and accommodation provided for the large number of members, but it was done most successfully, and the visitors had the pleasure of seeing Washington, spending an afternoon at White House and a morning at Mount Vernon, the home of General Washington, before starting its business at New York.

The Congress had one experience which it would have been glad to miss—a severe heat wave. The strangers felt it a good deal, but the hosts even more, as their work of organising was heavy and constant, and one of the kindest and most active died a few weeks later of typhoid, which he had caught during that time. Everything was done to make the occasion pleasant and memorable; perhaps the day that stands out most was an excursion by steamer up the Hudson, where the English guests saw, with the greatest interest, places long familiar by name, the Palisades, West Point,

Albany, and the landing-place associated with the tragic figure of Major André. The Congress ended on the 13th, and large excursion parties started in various directions.

The Ramsays' plans had been already made independently. They were due at Houston, Texas, on the 10th October, and had arranged to spend the intervening time at the Ranche[1] in Montana, so on the 14th September they started for the West by Chicago, but not stopping anywhere on the route. This was the second visit to the Ranche. The elder of Lady Ramsay's brothers, the first owner, was dead, and the younger one and his wife and children, and the widow of the brother Patrick, were now the ranche party. The house was much enlarged, and the surrounding country greatly altered by the construction of roads and the spread of cultivation. The use of motor cars also had changed conditions, and the feeling of isolation was gone. In the old days friends came generally with their bedding, so that when the house was full they overflowed into tents in the garden. Now they came by car, and could spend a day and go back in the evening, and the old Wild West rough and ready hospitality had been replaced by the hospitality of civilisation. There were other differences, however, that shed a new light on ranche life. In 1897 they had been out in the height of summer and for so short a time that holiday making was the rule, and it was the picturesque side of ranche life they saw;

[1] See page 202.

but for the purposes of the meeting he thought it necessary to be in New York itself, and as he had invited all the previous presidents who were attending the meeting to be his guests, there was a large party. The meeting was to have been opened by President Taft, but unfortunately he had an accident or illness and his doctors forbade him to travel to New York. With truly American promptitude and resource, the arrangements were changed, and reversing the Mahommedan tradition, as Mr. Taft could not come to the Congress, the mountain—that is to say the Congress—went to him.

All had to be settled very quickly, special trains arranged for, and accommodation provided for the large number of members, but it was done most successfully, and the visitors had the pleasure of seeing Washington, spending an afternoon at White House and a morning at Mount Vernon, the home of General Washington, before starting its business at New York.

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bright sunshine, cowboys dressed for the part, with flowers in their buttonholes and riding well-groomed horses.

In 1912 they saw the other side of the picture. Everything was late and harvesting had to be hurried, and the "boys" had to give up being picturesque and work their hardest. Then on the third or fourth day a heavy snowfall came, covering the entire country some inches deep. Sheep then had to be rounded up on the mountains and brought down into winter quarters, and last of all came the excitement of a supposed outbreak of swine-fever. The snow went as suddenly as it came, the swine-fever was a false alarm, but these few days gave an insight into the troubles of the simple life and the difficulties that had to be faced by the pioneers. The weather became lovely again, and Ramsay, whose love for animals was always very strong, found a new interest in the study of the colony of beavers which had been the irrigation engineers of the valley for many years. The Ranche lies among the foothills of the Rocky Mountains, and close to it runs in winter and crawls in summer a "creek," that is, a small river or large stream. Quite near the house the beavers have built a dam which has had the effect of widening out the creek into a small lake just where the water can conveniently be brought to the house and garden. The lake is covered with little islands, probably formed originally by the remains of earlier dams, silted up with mud and driftwood, and now overgrown with cottonwood trees and undergrowths

In these islands the beavers have their homes and live practically undisturbed. They have been such good friends to the Ranche that, so long as they confine their operations to the trees on their islands and do not attack those in the garden, they are not interfered with, and are consequently, if not tame, at least practically without fear. Ramsay used to lie for hours in the late afternoon hidden among the bushes on the bank, with his sketch-book and his devoted little companion, his nephew George Buchanan, and watch the beavers at their work. The melting snow had doubtless injured the dam and they were specially busy. The actual scene of operations was not visible, as it was hidden by vegetation, but on the islands the beavers could be heard breaking branches and soon would swim out trailing large boughs, which they took to the builders and returned against the current, empty handed, or rather empty-mouthed, for more.

Before leaving Montana, he was asked to give a lecture in Great Falls, the large town of the district and the seat of a great copper industry. He never addressed a more attentive or enthusiastic audience. The stay at the Ranche was prolonged till about a week before the opening of the Rice Institute at Houston, Texas. When he had spoken about this part of his plan the usual answer had been "I never heard of the Rice Institute. Has it anything to do with the Rice murder?" As Ramsay had never heard of that, the conversation on the subject dropped. Ramsay indeed knew very little

about what he was to expect from this part of his programme. Early in the year he had been officially asked to give three introductory lectures (to be accurate, to deliver one and hand in the others), and one or two others of his friends had been asked to do the same. Owing, however, to his having left London early in August, the full instructions had not reached him, and all he knew was that he had to be at Houston on the night of the 9th of October. Of Houston itself he knew little. One lady, with whom he had talked of it in London, had told him she had dined a few years before in its best hotel and that the mirrors had been all riddled with pistol shots after some gentle and joyous pastime of the night before. This account promised some excitement at least.

The origin of most of the American universities is very different from that of the ancient foundations in this country. They are very generally the outcome of private benevolence, often retaining the name of the founder, as at the universities of Harvard, at Cambridge, Mass., and Johns Hopkins at Baltimore.

One story about the start of one of these universities was told to Ramsay at Harvard. Some years ago the then president of Harvard was called on by an old couple, who asked if they might see over the university. They explained that they were interested in all young men for the sake of their only son, whom they had recently lost, and they looked so simple, so shabby and so sad, that the kindly President took them round himself. Their

criticisms and questions were simple like themselves. They did not take much interest in the intellectual work of the students, nor care to know which were the old buildings of the original foundation nor which college in Cambridge (England) gave the model on which the chapel had been built; they only now and then remarked, "This must have cost a great deal of money. Say, Sir, about how much?" Even at the last, when leaving the gates, their question was, "Just about how much would you say it would take to build this here place?" The President made some answer, wondering that their interest in education should only express itself in such financial queries. A little later he wondered no more: for the simple old couple who had called on him were the founders of one of the great universities of the Western States. The Rice Institute, which will doubtless one day be the Rice University, had a much more melodramatic history.

Towards the end of last century a certain Mr. William M. Rice, a citizen of Houston, announced to some of his friends that he was making a will, and intended to leave his fortune to found an Institute for the teaching of science in his native town. These friends were to form an advisory committee when the time came to take action. Not long after that he died under suspicious circumstances, and though the will was found, a newer one was produced, setting it aside, and leaving all the money to a lawyer who had done business for him. When the circumstances of his death were investigated

it was found that the old man had been murdered and the will probably forged. The legatee was arrested and tried and found guilty, but such was the ingenuity of the accused, that on small points of law the verdict was set aside, and the case was tried, retried and tried yet again, so that it was nearly twenty years before the money was set free for starting the Institute. During this time property in Texas had risen in value by leaps and bounds, and in consequence of that and the accumulated interest the trustees found a very much larger sum at their disposal than the testator had ever dreamed of. They had also ample time to think over the best use to which to put the funds, and they decided not to confine the teaching to science, but to make the programme more general, looking forward to a time when the Institute would become a university.

The first step the committee took was to appoint a principal—Dr. Odell Lovett—and then an architect—Dr. Ralph A. Cram, already well known in the first rank of his profession. A site was then selected, covering about five square miles of ground, about two miles from the town. The Principal was then sent off to visit the universities of Europe, Japan and America, to collect ideas and to determine what would be best, allowing for difference of climate and other circumstances. On his return he and Dr. Cram prepared a general plan of the whole, but provided that buildings should only be put up as required. The costs were paid out of income and not capital, surely a unique arrangement in matters

of the kind. The Principal then started off again on a tour to find a few members of staff to form a nucleus of the teaching body, and by the time he returned it became necessary to think of a formal opening. This Dr. Lovett wished to make as impressive as possible, and as Texas, in long vacation, is not very attractive to Americans, who know the heat of the Southern States, he felt something special must be done. In view of this he invited twelve professors of world-wide fame to give courses of introductory lectures, and trusted that their presence would attract eminent men from every part of the States in spite of distance and heat. The lecturers who accepted the invitation were Professor Altamira y Crevea, of Madrid; Professor de Vries, of Amsterdam; Professor J. W. Mackail, late of Oxford; Professor Stormer, of Christiania; Professor Emile Borel, of Paris; Senator Benedetto Croce, of Naples; Professor Sir Henry Jones, of Glasgow; Privy Councillor Baron Dairoku Kikuchi, of Tokio; Professor Ostwald, of Leipsic; Professor Henry Poincaré, of Paris; Professor Senator Vito Volterra, of Rome; and Ramsay himself. Professor Poincaré died in the early summer. The death of the Emperor of Japan prevented Professor Kikuchi leaving at the appointed time, and one or two others failed to appear, but those who were present had the warmer reception. Warm it was in every sense of the word.

All this, however, the Ramsays did not know till later, and they left Montana without having received any

letters as to arrangements for the celebration. As a matter of fact, the invitation proper and other directions had been sent to London in such a superior box that it was never opened, but put aside for their return. It is " a far cry " from Great Falls to Houston and involves a long cross-country journey, first southwards and then through the length of Texas. It was not much out of their way to stop at Denver and at Colorado Springs. Wherever Ramsay and his wife went they found old students, and at the latter place an old student invited them to lunch to meet Dr. Woodrow Wilson, not yet President, but on an election tour, and to hear him address a meeting in the afternoon. Ramsay, however, had arranged to spend the day in an excursion up Pike's Peak, and to see the Garden of the Gods. So he was obliged to decline the invitation. Had he foreseen the part which would be played by this man in the great European struggle it is likely that the Peak would have remained unvisited and the Garden of the Gods unseen. As it was the day was very wonderfully spent. Oddly enough the last signatures in the book of visitors to the hut were those of one of the Chemical Congress parties, which had made the longest tour and been there only the day before. From the top the view was magnificent. All about the nearer range were snow and cloud effects never to be forgotten, and, far away in the faint distance the peaks of the Sierra Nevada, like mountains in a dream. This was destined to be the nearest approach to the Pacific coast, which Ramsay

had always hoped to see. After Colorado Springs came the long and varied journey through Texas, beginning with the ranche country among the foothills and passing through wheat, cotton and sugar districts, till late in the evening of the 9th October they reached Houston, a large, flourishing industrial town, and the end of that stage of their journey. Though letters from Houston had not reached Ramsay, his communications had been delivered, and at the station they were met by the President, who drove with them to the house where they were to stay, and introduced them to their graceful and gracious hostess, the wife of Mr. James A. Baker, Chairman of the Board of Trustees of the new Institute. They were received in a large oak-panelled hall, hung with family portraits and a few good pictures, so that all idea of a shot-spotted mirror stage of civilisation went into oblivion at once.

Their fellow-guest was Dr. Henry Van Dyke, "that faithful, firm yet fervent minister and minstrel," [1] as he has been lately described. The first day in Houston was occupied with lectures, open to all, a Mayor's banquet, a garden party in the "Campus," the grounds of the college, and an evening reception of about fifteen hundred guests at the house of Mr. and Mrs. Baker. All the Trustees, all the Lecturers, and all the Delegates were supposed to stand in a line with the host and hostess and shake hands with the arriving guests. This is usual in America on occasions of the kind, and seems

[1] By the President of Magdalen, Oxford, in an address given in London January 1918.

to give great pleasure to those who are received. At the close of a long and strenuous day, however, "the receiving line," as it was called, found it rather trying and gradually melted away, but, entering into the spirit of the thing, Ramsay kept his place to the last. Next day there were more lectures, two in the morning and two in the afternoon, one of the latter being Ramsay's. After the lectures came a garden party, dinner, a chamber concert and a supper party, given specially to the inaugural lecturers. The last began about eleven, and the speeches which followed it lasted till dawn. They were all good and interesting, and no one noticed how the time had flown. The third day was appointed for the real inauguration. Ramsay had been present at several of the gatherings in this country to commemorate centuries of university history, but none were more impressive than this, looking forward to a great future. As yet there was no large hall, so the ceremony took place in the open air, in the shadow of the finest part of the buildings. The wide extent of the Campus, typical of the spacious years to come, the beauty of the buildings against the background of the tropical vegetation and the cloudless southern sky, the simplicity of the proceedings and the earnestness of all who took part in them, made it different from anything ever experienced before. There was first a short religious service, in which ministers of all denominations took part. Then Dr. Van Dyke read his beautiful ode on Texas, "The State of the Lone Star," then one of the oldest settlers

told his memories of the early days, and the meeting closed with the benediction. It was necessarily a short ceremony, for the shade of the buildings receding as the sun rose higher, the heat would soon have been unbearable; but it was indeed a great experience.

There was still on the hospitable programme an excursion to Galveston, the scene of the great tidal-wave disaster ten years before, with "a shore supper." Interesting, however, as that excursion might have been, the Ramsays were now due at Baltimore, and that night they started northwards, breaking the journey at New Orleans for a few hours.

At Baltimore they stayed with Ramsay's old friend, Dr. Ira Remson, the Principal of Johns Hopkins University, and Ramsay was at once surrounded by old students, old assistants and colleagues, and friends. They again missed meeting Dr. Woodrow Wilson, though they met Mrs. Wilson and her daughter. The university conferred on Ramsay the degree of Doctor of Science, and a more informal ceremony of the kind surely never took place. A special University Court had been summoned, but, being vacation time, many of the members were away, and the audience consisted mostly of old friends and a certain number of new ones. Everything was quite formal and academic till the capping was over, but then the speeches of the Principal and of the new *alumnus* were so full of old stories of their young days at the German university, when Remson "opened the door" for Ramsay into the world of chemistry, that

the audience was often convulsed with laughter. Tl friends spent one day at Annapolis, and Ramsay w. so fascinated with it that he often said it was the pla of all he had ever seen in which he would best like have ended his life. By this time it was drawing ne the date of his first Lowell Lecture, so with many regre the Ramsays bade farewell to the Remsons and the other Baltimore friends, and started for Boston, whe they took up their abode at the Somerset Hotel, a settled down for the next three weeks. Perha "settling down" is hardly the word to use, for t nights a week were spent by Ramsay in the train betwe Boston and New York, as he had been asked to gi a short course of lectures in Brooklyn, and he could or do it by fitting them in between his Monday and Thu day Lowell Lectures in Boston. He was a good travel and felt it no hardship, though he would have likec little more time for Boston social life.

Ramsay's friendship with President Lowell, Profes Lowell, the astronomer, and Professor Theodore Richar besides several other members of the Harvard st whose acquaintance he had made at the 250th anniv sary of the founding of the Royal Society, the sumn before, acted as an "open sesame" to that most exclus of circles, the intellectual world of Boston. Liter as well as scientific doors were thrown open to Ramsays, and they saw a new and very different s of American life. In a country where change a progress are so much in evidence, Boston, where the

families still live in the homes made famous by their ancestors, and keep up the tradition of simple and gracious hospitality without suggestion of rush or effort, has a special old-world charm of its own. Longfellow's house, where they spent an afternoon with a daughter of the poet, is left as it stood a great part of last century, with its "old clock on the stair" still ticking its "never for ever" as it did in his time. In every direction they were reminded of the great names of Boston's past. Time was made to pay a two days' farewell visit to Dr. and Mrs. Nichols in Brooklyn, and for a run to Philadelphia, where Ramsay received the Elliott Cresson Medal from the Franklin Society of Pennsylvania, the oldest society of the kind in the States. It was in returning from this visit that for the first time the Ramsays saw the beauty of the true American "fall," as the maples had just begun to change, and their colour was indeed dazzling in the clear bright air of the Indian summer then in its perfection. All this was a bad preparation for the voyage, which, like many return voyages, was dull and grey, not to be wondered at in mid-November, however, but giving the more time for "revolving many memories."

NOTE.—The proceedings at the inauguration of the Rice Institute are recorded with full detail in *The Book of the Opening of the Rice Institute*, the title-page of which also adds the following words: "being an account in three volumes of an academic festival held in celebration of

the formal opening of the Rice Institute, a university of literal and technical learning, founded in the city of Houston, Texas, by William Marsh Rice and dedicated by him to the advancement of letters, science and art."

These volumes contain the lectures given on the occasion by the eminent men who had been invited to assist by their presence and contributions. Volume three contains the lectures given by Ramsay, the titles of which are as follows: (1) The Electron as an Element, (2) Compounds of Electrons, (3) The Disruption of the so-called Elements. These lectures develop in greater detail the application of the ideas set forth in addresses to the Chemical Society of London already referred to (p. 181). They are purely speculative, but they illustrate the readiness with which Ramsay could turn from conventional views of chemical action, and the boldness with which he could develop hypotheses to fit the facts. It is true, as he says at the end of lecture two, that "the electron is no mythical conception, and that it enters into the constitution of matter is as certain as that matter exists." It does not follow, however, that there is much positive foundation for hypotheses as to their motions and combinations, and further study of the facts and phenomena connected with chemical action is necessary before solid ground is reached. Until the world settles down again to the peaceful occupations of civilisation there is not much prospect of advance in this direction.

CHAPTER X

THE END

A MAN'S character is not to be judged of solely from his actions. We require to know something of his thoughts, and especially of his opinions on fundamental questions of ethics, morals and religion. Such thoughts, however, are not commonly communicated to others, except in cases where a long intimacy of friendship, or the still closer familiarity subsisting between an affectionate husband and wife, leads to some disclosure of the inner self. We all know that attempts at such disclosure are seldom really successful, even when willing efforts are made on both sides. It is hard enough sometimes to know one's own mind and the sentiment by which one's actions are governed. These considerations must always clog the pen of the biographer, and no attempt at delineation of character can be more than partially successful. Perhaps the best test of such success is to be found in a comparison of the most prominent actions of the life with such record or indications as may be found to exist of principles professed.

Fortunately in the present case so many letters have

been preserved by the family and friends that there is abundance of evidence. William Ramsay came of a family more than usually distinguished by the affectionate regard of the numerous members of it for one another, and the freedom from those divisions which separate so many relatives, often for years or even permanently, for no reason which to the outside observer seems sufficient. An only child, his welfare anxiously watched over by affectionate and deeply religious parents, the influences which attended him in childhood doubtless retained appreciable hold on the general direction of his thoughts on religious and moral questions. There is reason to believe that very early in his manhood he began to consider these things, and though he soon threw off the restraints of the narrow evangelicalism (Calvinism would be the more exact word) in which he had been brought up, he continued all his life to conform to and value religious observances. At Tübingen he mentioned in his letters the services and meetings arranged by his American fellow-students, and he joined with them in these practices, beside attending the services of the Lutheran Church. And years later when he became Professor at Bristol and was living there alone, letters of his at that time refer to his attendance at the services in the Cathedral and to excursions to country churches. But all this time it cannot be doubted that the misgivings which had already begun to operate in his mind had slowly crumbled away his acceptance of many of the views and feelings under

the influence of which he had been brought up. We have the evidence of his old friend, Mr. Otto Hehner, in the sympathetic obituary communicated by him to the *Journal of the Society of Public Analysts*, that while still in the Andersonian College and not much more than twenty years of age, the two young men discussed philosophical questions, the one "influenced by inheritance from Covenanting ancestors," the other by that "from unorthodox and agnostic surroundings."

Let not any reader suppose from this that Ramsay at any time of his life drifted so far away from orthodoxy as to join "with men who make a mock of holy things." Such an attitude would be rare, even at the present day, though there are still too many people who misunderstand and misrepresent the position of men of science, forgetful of the fact that of all men they are the best qualified and the most disposed to feel the awe of the great mystery in which man's life, and the purpose of all being, is immersed and enveloped. *The Creed of Science* has been used as the title of a book. But such a phrase is very difficult to interpret. It seems to imply that science is stationary, whereas the characteristic of all science is progress; if there were any fixed tenet which could be attributed to science or to scientific men as a body, it would at once become associated with authority, whereas science submits to no dicta and to no dogma.

The position reached by Ramsay seems revealed in a

letter to Professor Worthington, dated Boat of Garten, 14th September, 1903. After remarks about the weather and the doings of friends, he proceeds :

"This is Sunday and I am going to continue our conversation of three weeks ago, and give you two quotations, one neutralising the other, I think. The first is from W. H. Howells,[1] and is called 'The Bewildered Guest':

'I was not asked if I should like to come,
I have not seen my host since here I came,
Or had a word of welcome in his name :
Some say that we shall never see him ; some
That we shall see him elsewhere and then know
Why we were bid. How long I am to stay
I have not the least notion. None, they say,
Was ever told when he should come or go ;
But every now and then there bursts upon
The song and mirth a lamentable noise,
A sound of shrieks and sobs that strikes our joys
Dumb in our breasts ; and then some one is gone.
They say we meet him, none knows when or where ;
We know we shall not meet him here again.'

The second is in *Paul Kelver*, by Jerome K. Jerome, a book which I strongly recommend, if you haven't read it already:

'"What do you believe," I asked, "father really, I mean ?"

The night had fallen. My father put his arm round me and drew me to him, "That we are God's children, little brother," he answered, "that what He wills for us is best. It may be life, it may be sleep ; it will be best. I cannot think that He will let us die ; that were to think of Him as without purpose. But His uses may not be our desires. We must trust Him. 'Though He slay me, yet will I trust in Him.'"

[1] Is this not W. D. H., American novelist and poet ?

We walked awhile in silence before my father spoke again.

"'Now abideth these three: faith, hope and charity'—you remember the verse—faith in God's goodness to us, hope that our dreams may be fulfilled. But these concern but ourselves—the greatest of all is charity."

"Be kind, that is all it means," continued my father. "Often we do what we think right and evil comes of it, and out of evil comes good. We cannot understand—maybe the old laws we have misread. But the new law that we love one another—all creatures He has made—that is so clear. And if it be that we are here together only for a little while, the future dark, how much the greater need have we of one another!"'

I think there is little more to be said. Indeed, it is all the Law and all the Prophets."

That this found response in his own soul there can be no doubt. He took the trouble to write it all out again in a letter to Mr. Hehner about the same time.

> "He prayeth well, who loveth well
> Both man and bird and beast.
> He prayeth best, who loveth best
> All things both great and small;
> For the dear God who loveth us,
> He made and loveth all."

This was the practical precept of his life.

How such a view harmonised with his own nature is illustrated in many an act of charity and benevolence. He never shut his ears to any tale deserving of pity. But many people who have similar charitable impulses draw the line at misfortunes which people bring on themselves. It was not so with Ramsay. An employé of a society with which he was connected was

discovered to have falsified the books and to have misappropriated moneys entrusted to him. After his defalcations were discovered Ramsay, fearing he might contemplate suicide, went to see him at his house, urged him to make a clean breast of it, and afterwards did everything in his power to win him back to ways of honesty and give him a fresh start in life. Two other cases of a similar kind may be mentioned. One was that of a friend who met with misfortune in business, took to drink, and gradually sank in the social scale. He emigrated subsequently to America. Many people would have been glad to be quit of a friend who might have become very troublesome. That was not Ramsay's way. When he visited America he sought him out and did what was possible to relieve him. The other was a case of matrimonial trouble. The husband was the flagrant offender. He occupied a good position originally, which he forfeited in consequence of the irregular habits into which he fell. Ramsay spared neither time nor trouble in his efforts to reclaim him, and that at a time when he was immersed in his researches and in university business. Other cases are known to his friends, but for obvious reasons details cannot be given in these pages. But to omit notice of these facts would be to do less than justice to this fine feature of Ramsay's character. He was always on the side of the weaker brethren and ready to take the trouble, from which so many others shrink, to sustain by words of sympathy and to give the practical help, without which words too

often seem to be a mere mockery of suffering. On this subject his old friend Sir James Dobbie writes:

"He often spoke to me with great feeling of the miseries inflicted on certain families known to us both by the irregularities of certain of their members, but his sympathies seemed always to be divided between the sinners and those sinned against. He had a strong belief, as you know, in the transmission of ancestral qualities by heredity, and it may be that his views on the subject of personal responsibility were influenced thereby. But I am inclined to think that his conduct in such cases was prompted solely by his large-hearted human sympathy and was not influenced, at least consciously, by any scientific theories."

The views about heredity here referred to are clearly expressed in the early part and are again hinted at in the concluding words of the autobiographical sketch contributed to the volume already referred to, "Vergangenes und Künftiges aus der Chemie." The following is a translation of the last paragraph:

"In conclusion I should like to quote a passage from Robert Boyle, which, however, I have slightly altered. 'To have been the son of such parents as were my father and mother, to have had such a helpmate as my wife, has brought me happiness which I must acknowledge with the greatest thankfulness: my birth and career agree so closely with my inclination and views that if a choice had been permitted to me I could hardly have wished to change the ordinance of God.'"

There is no need to enlarge further on this side of Ramsay's private life. Whatever acts of benevolence he did were performed quietly and unaffectedly and were known to few even among his friends.

Another characteristic was his perennial cheerfulness

and readiness to take part in and contribute to the gaiety of others. That he often displayed a lively humour has been shown in some of the quotations from letters already given. One more example may be recalled. In 1897 the family had all taken to cycling and Ramsay wanted to give a bicycle to his cousins. Instead of sending it to them he sent it to his aunt (Lady Ramsay) with the following note :

"12 ARUNDEL GARDENS,
20th Decr., 1897.

MY DEAR AUNT LOUISA,

You will receive a 'parcel,' it may be to-day it may be to-morrow, which you will not think pretty, and which you will not find useful. You mustn't give it away; that would be to slight the giver, but you may lend it freely. One of its advantages is that though there isn't much of it, the little there is will go a long way. You can blow her up when she displeases you. She is always tired and yet never unwilling to go. Though she is entirely without grit, she has a good deal ot backbone; though unmarried, still she has two hubs. I hope you may never have to put a spoke in her wheel. Etc., etc."

In a similar spirit he took the trouble to write a whole letter in rhyme to the daughter of a friend, Dr. W. E. Adeney, who had apparently given him a hint that he ought to shave.

His knowledge of languages and familiarity with so many tongues led him into frequent little jokes with his friends. At one time he addresses postcards in Latin to Professor Smithells in mock grandiloquence, "Tibi gratias, o vir eruditissime, propter tuam epis-

tolam, etc." At another time he writes to his cousin in a language which we may suppose to be Esperanto (?):

"MI CAR DORA,—Io hab recip vestr litr, ke era mult facil a comprendar, etc."

And among letters to his Cousin Ella are many in which this frolicsome spirit is a feature. One begins thus:

"Mein theurestes Kind? Wie geht's dir? Combien te portetu, ma chère? Come sta, ma carissima? How are you, my dear child? and you may imagine yourself chucked under the chin if you have strength of imagination for it"

And so on.

After he was grown to man's estate Ramsay did not change much physically. An athletic frame capable of great exertion in walking, rowing or swimming, as already mentioned in earlier pages, was associated with a quick step, alert manner and usually cheerful spirits. With fine expressive eyes, he had the habit of elevating one eyebrow or the other, which often preceded some quizzical remark or even some momentous pronouncement. His amusements were of a simple character, such as tennis or boating. He was never interested in what is called sport, and never carried a gun. His fondness for music and his accomplishments in that direction have already been sufficiently mentioned. In early life his interests were confined chiefly to his chemical work and to the happenings in the university and social circles in which he moved. He troubled himself little about politics in those days and never meddled to any

serious extent, as so many of the younger men did, with questions of reform which were then troubling the Scottish universities. Later in life his interests widened and he occupied himself, as already related, with many questions, especially such as related to education. His taste in books was always a catholic one. Scott was a great favourite, and during his last illness he had many of the Waverley Novels read to him over again.

His taste for languages led him to interest himself in his later years in an attempt to devise a new universal language, written but unspoken, utilising the fundamental idea of hieroglyphics, a sort of modern Chinese. A rough figure represented a man, an arrow indicated the man's intention to do something indicated by another figure, the direction of the arrow was used to suggest the future or the past tense of the action. Such a symbolism was expected to convey ideas to the stranger, which he would express in his own language, be it English, French or Arabic. A friend writes *à propos* : "One night I found him studying Chinese and Egyptian grammar! He said Egyptian was very easy, but he confessed that Chinese was rather stiff. He was making preliminary studies for his philosophical universal language in this way."

The absorbing interest of his life was scientific research. With what ardour, interest, patience and skill he followed the path of discovery has been sufficiently shown in what has gone before. This led quite naturally to an acquaintance with a very large number of men of science,

and the number of these was so much the greater because he could use the language of everyone. This led to his being invited to lecture on his work many times in Paris and several times in Berlin, so that the circle of acquaintance continually widened, and many cases of mere acquaintance ripened into friendship. Hence he had a large correspondence with friends in other countries, in addition to the constant exchange of letters with his relatives and several friends, with whom he had kept up unbroken communication from the time of his youth. And he was a delightful friend, always cheerful, inspiring, enthusiastic, full of ideas, and ready to give information or discuss any difficulty. A very rapid worker in experiment, and possessed of a remarkable skill in working glass and fitting together glass apparatus.

Naturally many honours fell to his lot. Of these perhaps the most notable was the Nobel Prize, not merely on account of its considerable pecuniary value (nearly £8000), but by reason of the deliberation and formality which precedes the award. In 1896 he was made Officier de la Légion d'Honneur; a K.C.B. in 1902; a Commander of the Order of the Crown of Italy; Knight of the Prussian Order "Pour le Mérite"; and received honorary degrees or honorary membership from a large number of universities and academies. A complete list of these distinctions is given at the end.

Notwithstanding the strenuousness of his life and the immense labour given to his teaching and research, Ramsay retained generally good health and showed

little sign of exhaustion of bodily or mental powers down almost to the last six months. Work had been going on as usual at college down to the time of his retirement from the Chair of Chemistry. On the 10th December, 1910, however, he wrote to Professor Smithells:

"I have been hovering between life and lumbago for some weeks, and yesterday I was in bed trying to get some ease. . . . In fact, unless I call a halt for a bit I shan't need to call one at all, for I am awfully played out. . . . I have no doubt that a decent rest will pull me up, and I am going to try during the holidays to do nothing for a bit, but I have the B.A. address on me and half a dozen other things more or less pressing. One is the liberation of the radium lent by the Austrian government, or its return to Vienna on demand. That in itself means a fortnight's hard work."

That Ramsay's life was on the whole a very happy one there is abundant evidence. The letters quoted show it, and his own definite avowals at the end of the autobiography (quoted p. 295) and in letters to friends during his last days prove that he thankfully acknowledged the happiness which life had afforded him. In writing to a friend (February 1908), this is how he expressed himself:

"Yes, it is thirty years since you and I first smelt the Liffey. Life has been pretty good to us—perhaps I should say 'God.' I feel inclined to. You have had a terrible trial which I have been spared; but you have got a good son and daughter, and that is much to rejoice at. So have I. Just think what it would be if it were different. I can't think of anything more heart-breaking."

He had been engaged from early youth onward in pursuits of his own choosing, and at every step he enjoyed the satisfaction of knowing that in these pursuits he was achieving something, that he was, in fact, on the path of discovery. It is only those who have joined in serious attempts to solve the problems presented by nature, or what is called "scientific research," who can understand the exultation which fills the heart at the moment of success. Honours or rewards which may follow are not thought of. And the triumph belongs not only to the "watcher of the skies," but is shared by the humblest discoverer of things on the earth.

Testimony to this feeling is not wanting in the utterances of men of science. In the Memorial Lecture given by Ramsay himself to the Chemical Society in 1912, after the death of his friend Moissan, he quoted the following words from the preface by Moissan to his book on the *Electric Furnace* :

> "But what I cannot convey in the following pages is the keen pleasure which I have experienced in the pursuit of these discoveries. To plough a new furrow; to have full scope to follow my own inclination; to see on all sides new subjects of study bursting upon me, that awakens a true joy which only those can experience who have themselves tasted the delights of research."

Ramsay was ever filled with that divine curiosity which in spite of obstacles impels the discoverer forward. None of the common impediments stood in his way; there was neither poverty, nor ill-health, nor discouragement from friends, nor family cares. He was in due time

happily married and the comradeship which subsisted between the husband and wife is illustrated throughout by the letters, some of which have been quoted, showing that she was always the first to hear news from the laboratory, as well as to be consulted on all the concerns of their family life. His pride and happiness in the doings of his two children when young is also shown in many letters. Ramsay was spared to practise *l'art d'être grand-père*, for his daughter married happily in 1906 and grandchildren came to enrich the family circle. It was a great pleasure to him that during what may be called the last happy summer of his life, that of 1913, before the war cloud gathered, he had the children with him, and introduced them to the delights of a holiday in the Highlands. His old and ever kind friend, Sir Andrew Noble, had lent him a lonely old castle on a rocky promontory on Loch Fyne. It had till then been a ruin and had only just been restored, and in this romantic setting he was able to give his grandchildren their first experiences of swimming and rowing and the management of boats. It would be difficult to say which was the happiest of the party.

That Ramsay had long ago gained experience in the ways of children, and profited by it, is shown by the following passage contained in a letter to Dr. George M'Gowan so long ago as March, 1886, when his own son and daughter were children:

"I think you will, if your experience is like mine, find a young human being a very uninteresting person for a year and a half.

But after that one begins to feel the responsibility of a father and the interest grows. We have got to the story stage now and the constant and never-ceasing demand is, "Tell me what you did when you were a little boy." And no amount of anecdote satisfies that craving, so I sometimes desert the sure path of truth and wander in the romantic groves of fiction. But it is a dangerous process, for the verbal memory of youth is wonderful and if one tells the story with the slightest variation the youthful mind refuses to accept the innovation and insists on the same facts being told in the same words; and when these same facts are fiction it is a little difficult to do so." Quite

He and his wife had long established a reputation for hospitality, and when he retired from the Chair at University College they hoped to gather friends about them in the pleasant country home at Hazlemere in Bucks, to which they had so recently removed. This, however, was not to be, but even in the misfortune which overtook him and ended his life in months of physical misery, the survivors may try to extract consolation from the thought that he was spared the years of "slow consuming age," the weary watching of declining powers which are the lot of many for whom the "fell sergeant" is less swift in his arrest.

Dr. Johnson, who had ready-made views on every subject, is said to have maintained that, in writing a Life and not merely a Panegyric, an intimate friend should endeavour to represent it as it really was and should mention faults. In the present case it is not easy to comply with this precept, not because the subject of the memoir had no faults, for to say so

would be to proclaim him more than man, a character to which he would have been the last to lay claim. But this may be asserted with the utmost security that such faults as he had are hard to discover, and whether they concerned his scientific work, his public life or his private conduct, they were not such as to attract the open censure of his contemporaries. Some twenty years ago an anonymous attack on him was unfortunately admitted into the pages of the *Chemical News*. Its authorship and origin were easily recognisable, but Ramsay paid no attention to it. His friends were satisfied that there was no justification for the allegations and expressions thus brought forward and which could only be regarded as discreditable to the writer. The immense circle of his intimate friends and correspondents is sufficient evidence of the virtue that was in him. Here is a portion of a letter from a scientific man who had known him from the old days in Glasgow University:

"He was then as always a delightful companion, full of gaiety and kindness. It was wonderful to see how absolutely unspoiled as a friend he remained amid the shower of honours that came upon him. He was never with people too important to give him time to welcome in his radiant way an old acquaintance. Memories flow in upon me, for I saw him in many vicissitudes and many were the happy hours I spent with him."

That his actions on one or two occasions exposed him to criticism is no doubt true, but such imprudences are attributable wholly to the exercise of that abundant good-nature which was a characteristic. He sometimes allowed himself to be approached too readily by the

professional interviewer, forgetting how easy it is for the newspaper man eager for "copy" to exaggerate and distort words uttered in conversation as freely as if spoken to a friend. He was always optimistic in his view of what was possible in the application of science to practice, as, for example, in his proposal to submit coal to distillation *in situ*. And he was sometimes too eager to get things done and was impatient of the cautious and apparently dilatory attitude of the majority of men of business. This led him on more than one occasion to embark on schemes into which he did not hesitate to fling money of his own, but which were in some cases predestined to disappointment.

Notwithstanding the extraordinary fame of his long series of brilliant discoveries, Ramsay never showed that the height to which he had risen in the eyes of the world lifted him beyond the range of old friendships. Although he left Glasgow in 1880, he kept in close touch all through life with many of the friends of his youth there and was never happier than when in their company, recalling memories of the trials, humours and triumphs of the old days when he was assistant to Professor Ferguson. To his students he was the same sympathetic and kindly teacher at the end as at the beginning of his career, while to his contemporaries he was always friendly and courteous. His spirit and his enthusiasm for scientific research have left their deep impress on students young and old, and through them will pass on to future generations.

We look back over the centuries and among the founders and master builders of their science we see the outstanding figures of Boyle and Black, Lavoisier, Priestley and Scheele, Cavendish, Davy, and Berzelius, with a few more. The stream of time bears along to oblivion the vast majority of the sons of men, and though in this age of scientific activity there is an ever-increasing army of workers, most of them are engaged in supplying merely the bricks of which the edifice of scientific knowledge is built. They have their reward in their own day and generation. The name of William Ramsay will always stand among those of the Master Builders.

HE hath shewed thee, O man, what is good; and what doth the Lord require of thee, but to do justly, and to love mercy, and to walk humbly with thy God.

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ADDENDUM

LIST OF SIR WILLIAM RAMSAY'S HONOURS

Degree of Ph.D Tübingen	1872
German Chemical Society Member	1872
Chem. Soc. London Fellow	1873
Phil. Soc. Glasgow Member	1875
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